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Two self-propelling SUCTION DREDGERS with radial heads and pumps having 20in. diameter suction and delivery, also floating discharge pipes, terminal pontoons, anchor lifting pontoons and floating high pressure hydraulic pumping plants.
Tender forms will be obtainable on the 11th August, 1924, at the above address. F 506

THE SOUTH INDIAN RAILWAY COMPANY LIMITED, are prepared to receive

Tenders for the Supply of:—

100 WAGONS OF SORTS.
Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.
Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked:—"Tender for Wagons," must be left with the undersigned, not later than Twelve Noon on Friday, the 10th October, 1924.
The Directors do not bind themselves to accept the lowest or any Tender.
A charge, which will not be returned, will be made of £1 for each copy of the Specification.
Copies of the Drawings may be obtained at the Offices of the Consulting Engineers to the Company, Messrs. ROBERT WHITE & PARTNERS, 3, Victoria Street, Westminster, S.W.1.
A. MUIRHEAD,
Managing Director.
91, Petty France,
Westminster, S.W.1.
5th August, 1924. F 509

DREDGER.
BRITISH MANUFACTURE ONLY.

The Lee Conservancy Board invite

Tenders, Designs, and Specifications

for a STEAM LADDER BUCKET DREDGER, 80 ft. long, by 13 ft. Beam, depth middle line 4 ft. 6 ins., draught not to exceed 3 ft., to dredge to a depth of 12 ft. and raise not less than 65 tons per hour, to load into barges 4 ft. 6 ins. above water line and to be forward cutting to cut its own flotation. The framing and gear to be easily lowered so as to pass under bridges 6 ft. 9 in. above water line.
The hull to be of Steel to Lloyds' Specification with accommodation for two men to sleep on board. State time of delivery afloat ready for work on the Lee Navigation at Bromley Lock, Bow, London, E.
The Board do not bind themselves to accept the lowest or any Tender and all designs offered are to be at the expense of the persons tendering.
Tenders, Designs and Specifications giving full particulars to be delivered in sealed envelopes marked "Dredger," not later than September 25th, 1924, to
CHARLES N. TWEEN, M.Inst.C.E.,
Engineer & Manager to the Board,
Enfield Lock, Middlesex. F 519

STATE ELECTRICITY COMMISSION OF VICTORIA.
Melbourne,
Victoria,
AUSTRALIA.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.
Copies of Tender Form and Specification will be available upon application to:—
AGENT-GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C. 2.

SPECIFICATION No. 24/68—
22,000 VOLT. INSULATORS.
CHARGE:—£2 2s. for the first three copies of Tender Form, Conditions of Contract and Specification complete. This charge will be returned on receipt of a *bona-fide* Tender. A fourth copy, and any further copies, will be supplied for the sum of 10s. 6d. each. This charge is not returnable.
PRELIMINARY DEPOSIT:—A Preliminary Deposit of £100 is to be lodged with Tender.
The Specification may be inspected at the above-mentioned office.
The Commission does not bind itself to accept the lowest or any Tender.
Tenders on prescribed form, properly endorsed and addressed, must be delivered to the undersigned in Melbourne not later than Five p.m., 20th October, 1924.
R. LIDDELOW,
Secretary. F 481

PORT OF BRISTOL.

TWO SELF-PROPELLED STEEL HOPPER BARGES.

The Docks Committee invite

Tenders for the Construction,

DELIVERY and MAINTENANCE for twelve months after delivery of TWO SELF-PROPELLED STEEL HOPPER BARGES of 60 tons capacity.
On and after Monday, the 11th day of August, 1924, copies of the Specification and Contract Drawings, etc., can be obtained from the undersigned on production of a receipt showing that a deposit of £5 has been paid to the Bristol Docks Committee, to whom all cheques must be sent and made payable. The deposit will be returned to *bona fide* Tenderers after the receipt of the Tender with all the prescribed documents and Drawings.
The Tender must be enclosed in a sealed envelope endorsed "Tender for Two Self-Propelled Hopper Barges," and addressed to the General Manager and Secretary of the Docks Committee, 19, Queen Square, Bristol, and must be delivered to him, accompanied by all the prescribed Documents and Drawings, before Ten a.m. on Monday, the 1st day of September, 1924.
The Docks Committee do not bind themselves to accept the lowest or any Tender.
THOMAS A. PEACE,
Chief Engineer.
Chief Engineer's Office
Avonmouth Dock,
Bristol.
8th August, 1924. F 518

The Director-General,

India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E. 1, REQUIRES:—
GIRDER BRIDGES, four 83 ft. span.
Tenders due on 22nd August, 1924.
Tender forms obtainable from above. F 523

SOUTHAMPTON CORPORATION WATERWORKS.

TENDERS FOR PIPES AND SLUICE VALVES.

The Corporation invite alternative

Tenders for the Supply of

about 2000 yards of 36 in. PIPES, about 6250 yards of 33in. PIPES, and about 100 tons of SPECIAL CASTINGS:—
(a) Ordinary S. & S.C.I. Pipes for lead joints.
(b) Double spigot pipes with turned beads for Victaulic Joint and Victaulic Joints complete.
(c) Steel Water Pipes with Victaulic Joints complete.

Specification, Conditions of Contract, Bill of Quantities and Form of Tender may be obtained at the Waterworks Offices, 21, Shirley Road, Southampton.
The Corporation also invite alternative Tenders for the SUPPLY of various SLUICE VALVES tested to a pressure of 600 feet head:—
(a) Double Socket Valves.
(b) Double Spigot Valves with turned beads for Victaulic Joint.

Particulars may be obtained from the Waterworks Engineer.
Sealed Tenders suitably endorsed must be delivered at the Town Clerk's Office, Southampton, by Ten a.m. on the 4th September next.
No pledge is given to accept any Tender.
R. R. LINTHORNE,
Town Clerk.
2nd August, 1924. F 511

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UNIVERSITY COLLEGE OF SWANSEA.

Applications are Invited for

the POST of LECTURER in CIVIL ENGINEERING. Salary £500 per annum. The appointment will date from October 1st, 1924.
Further particulars may be obtained from the undersigned, by whom applications must be received on or before August 23rd, 1924.
EDWIN DREW, Registrar.
Singleton Park, Swansea. F 409

UNIVERSITY OF LONDON—GOLDSMITHS COLLEGE, NEW CROSS, LONDON, S.E. 14

Applications are Invited for

the POST of EVENING LECTURER in Theory and Design of Structures Mondays and Thursdays, from 7.0 to 9.30. Remuneration will be at the rate of 22s. per evening. For forms of application, and a more detailed statement of duties, apply to THE WARDEN, Goldsmiths' College. F 522

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QUIRED by the GOVERNMENT of BRITISH GUIANA for two years' service with prospect of permanency. Salary £600, rising by annual increments of £25 to £650 a year. Candidates, preferably single, must be A.M.I.C.E. and have had good engineering experience preferably with a Municipality or large Public Works Contractor. Age 25 to 35. Apply at once by letter stating age, whether married or single, and giving brief details of qualifications and experience to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1., quoting clearly at head of application M/12988. F 544

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Applicants must be experienced in precision work at the bench and machines, and have had some technical training.
Apply, in writing only, stating qualifications, experience and wages expected, to THE WARDEN, Goldsmiths' College. F 521

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at once for Restoration of Bideford Long Bridge. (Reinforced Concrete). Contract now proceeding and expected to finish about January next. Applications stating salary required and enclosing testimonials to reach the undersigned not later the 18th August, 1924.
H. M. BAZELEY,
Bridge Steward,
24, Bridgeland Street,
Bideford F 542

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RUTHERFORD TECHNICAL COLLEGE.

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Applications (on form to be obtained by sending stamped addressed foolscap envelope) to be returned to the undersigned not later than Tuesday, 19th August, 1924.
THOS. WALLING,
Director of Education.
Education Office, Northumberland Road. F 416

Assistant Locomotive

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Assistant Engineer

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THE SOCIAL REACTIONS OF CHEAP POWER.

By F. A. Macquisten, K.C.

One of the features of industrialism on the Continent is its combination with rural life. A little factory is in nearly every village. The workers have their bit of land to grow their own food on their own time and to keep them employed in slack times. They are near to their work and can walk to and fro for their meals, and their employers dwell amongst them. In Britain the workers are concentrated in masses in industrial towns, in towns like Glasgow, piled in tenements on the top of each other. Housing schemes to add more houses to such towns will merely add to the clamant evil of density of population. Working men cannot afford to live out of town and travel to and fro and feed in clubs and restaurants, and working women cannot be expected to prepare an evening dinner in addition to the children's midday meal. Even employers who seldom dwell among their own people, as in France, but live in the west end, or travel thirty miles or more into country districts, are finding the trouble of the evening meal increasing; the difficulty of domestic service is getting more and more upon their wives' nerves. The workers, left to themselves entirely, without their natural guardians, their employers, and owning nothing but their sticks of furniture in a two-roomed highly-rented house, are unhappy and an easy prey to agitators and Bolshevist propaganda.

Britain was the pioneer of rail transport which concentrated the people in the big towns, and by taking advantage of the early prejudice against the locomotive on the highway, the railway companies secured that steam transport thereon was forbidden by Parliament. Had steam road transport, already nascent, been allowed, industries would have gone to population instead of population to industries, the agricultural population would have been interwoven with the industrial, the consumer and the producer from the land, would have lived side by side, the middleman and the retailer who engross the main proceeds of agriculture would have been less like the locusts, and the happiness and standard of life of the people would have been more secure. The problem of roads for the internal-combustion vehicle would have been solved long prior to the advent of the motor car. It is, however, no use "jobbing" backwards. The problem is how best to repair and how to avoid repeating the errors of the past. There is grave danger of doing the latter in these times. If power, heat and light can be provided cheap enough the evils that I have described can be abated, the population can be de-urbanised to a great extent, with lasting benefit to the health and social condition of the people. The puzzle is how to begin. A false step now will put us on the wrong road for all time. I believe we will make a false step if we merely erect power stations and wait for custom. They will be burdened with heavy oncost and capital charges before they get it, and will never produce power at the cheapest rate.

If a rubber planter is fortunate enough to have located land with a climate not only apt for rubber but capable of yielding catch crops of maize, cotton, hemp, tobacco or other tropical crops, yielding revenue during the decade when his rubber trees are growing to full fruition, his capital outlay on his rubber estate at the end of the decade will be 75 per cent. less than it would if he had merely planted his trees and waited. He can with confidence and with the same capital exploit a larger area than is possible without these earlier crops. Can the same mercantile principle not be applied to the question of power production? It is a maxim of industry that cost depends upon turnover. With a small turnover, overheads and profits may constitute a very substantial percentage of the price, while a vastly increased turnover may reduce these constituents to a very small amount of it.

The Ford car is the classic instance. Ford did not ask what it would cost to make a car, but rather what are the majority of Americans able and willing to pay for a car. A question in these latter terms does not appear to me to have yet been put to themselves by the power producers of this country. They are not in a position to put it. For power stations are costly, and they have to fix a price which will cover the cost of production, and supply only the limited and slowly accruing market which is able and willing to pay that price. They naturally go where the population and the industries are, and build up a clientele. If the latter was to hand, ready at once to consume, they could erect a plant a little in excess and get immediate revenue, like the catch crop rubber grower, and they could dump their excess at such a price that custom would spring up overnight. The clientele is to hand in the railway companies. I am told, in an address by an eminent American electrical railroad expert, that an electric railroad is three times more efficient than a steam railroad, while the terminals—in this country so large in some places as to be unmanageable—are, when electrified, six times more efficient. It must pay them to electrify. But they will insist on doing it themselves, as the London District and Tubes do. They will not be the vassals of power companies. I believe one railway does buy power, but it is not considered a provident arrangement in railway circles. Having been electrified, and so carrying power for their own uses into every town, village and hamlet in the kingdom, is it not a natural and economical sequence that they should sell power to the districts through which their systems run? Could they not sell it at prime cost and without any addition for overhead and management charges, already provided for in making for their own needs.

No power company would carry a cable to any district unless assured of custom in the immediate future. But the railway cable will be there whether or no, and any custom, however small, is a find for them, and they would in the course of nature keep their rates to the figure that would secure it. I mean no mischief to the power companies, for they would function as at present; but as a part of the railway enterprise, which would take them over on liberal terms. Their experts would carry on their daily job with greater security and with increased emoluments arising out of the increased magnitude of their task. New little communities would spring up in the sparsely, relieving the congestion in the densely, populated centres. If cheap enough, the housewife would lighten her task by cooking and heating from the railway supply. Power would be applied to agriculture as well as to industry. Even the motorist, mistakenly regarded as the rival instead of by dispersion of population the creator of new rail transport wants, would no longer need to change gears but would change standardised batteries at any railway station instead of filling up with petrol. That there would be difficulties I have no doubt, but I have sufficient confidence in our electrical experts to believe they can solve them. Both the railway and the electrical workers of so immense and vital a public utility as would be created, would need to come under legal conditions similar to those of the police and gas and water undertakings, and the prices charged would be regulated by some tribunal.

I am not writing as an expert electrician, being neither an electrical engineer nor a railway man, but as a member of the public, and as a politician and student of the social condition of the people. I was fiercely attacked by an ex-president of the Institution of Electrical Engineers as one of the "singularly ill-informed members of the public," for daring to give expression to the above views in a popular newspaper. He took the erroneous view that in so doing I was attacking the dignity and status of his profession. Precisely the contrary is the case. By vesting them at once with the enormous custom of the railway companies as the wayleave to the still greater clientele of the whole community, they will become the creators of new and happier conditions when field, factory and workshop will be brought into close communion, the town and the country will at once be garden and hive of industry, instead of being sundered and antagonistic as now. Surely, in endeavouring so to do I, as St. Paul said of himself, seek to magnify their office.

THE NAVY AT THE BRITISH EMPIRE EXHIBITION.—III.

In the main avenue of the Palace of Engineering is the exhibit of Sir W. G. Armstrong, Whitworth and Co., a firm which owes its existence chiefly to the efforts of Lord Armstrong, Sir Joseph Whitworth and Sir Andrew Noble, three pioneers in the development of modern artillery. Started in 1847, its business rapidly developed, and at the present time the firm's extensive works are capable of building the largest size of warship complete with the necessary armour, armament and propelling machinery. The activities of the firm are not by any means confined to war material, for all types of mercantile vessels from the stately passenger liner to the ordinary tramp steamer are built and completely equipped at their two shipyards on the Tyne. A thorough inspection of their extensive exhibit reveals many other important branches of engineering in which the firm is engaged.

One of the firm's exhibits is of some historical interest not only as marking an important stage in the evolution of artillery, but also as being the first notable armament production of Armstrong, the former Newcastle solicitor, and one which started the builder and his firm on the high road to fame and fortune. It is known as No. 1 Gun, and its successors from the same works must by now be numbered in tens of thousands. The Battle of Inkerman was fought in November, 1854, and in the following month, shortly after dispatches relating to the operations had been received, Mr. Armstrong had an interview with the Duke of Newcastle,

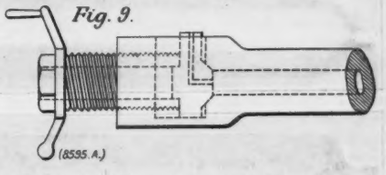


Fig. 9.

the Minister of War. As a result No. 1 gun was designed, constructed and ready for trial in the following June. Its trial results were so successful that an order for a large number was given to the firm and the Army and Navy supplied with them. It is a three-pounder gun, with a bore slightly less than 2 in. in diameter. The barrel is of steel, strengthened with coiled iron cylinders shrunk on to the barrel and over one another. It is rifled, was made for breechloading, and it fired an elongated projectile, as now used, in place of the round shot then generally employed. The simple and efficient breech mechanism rendered it also a relatively quick firer. Rifling and elongated bullets had previously been adopted for small arms, but although experiments had been carried out, rifled guns of larger calibre had not been a success. Breechloading had been used four centuries previously, as in the peterara in the Government Pavilion, but had been abandoned by the end of the 16th century. No. 1 gun was thus a reversion to type. Like the old gun, it has a recess in its breech end, and into this there is shipped vertically a light portable block containing the vent and termed the vent block (Fig. 9). This block has a conical projection on its face which fits into a corresponding recess at the breech end of the bore, the fitting surfaces being covered with copper sheet. The block is forced into position, and held firmly when the gun is fired, by a screwed spindle working in a nut formed on the breech end and turned by a lever and handle. The spindle of the screw is hollow, the hole through it being of sufficient diameter to allow of the projectile and charge passing through into the bore with which the spindle is in line. When loading the gun the vent block is lifted out, the projectile and charge passed through and rammed home, the vent block replaced and forced into position by the screw, and the gun is ready to fire.

The rifling is entirely different from the systems previously tried to give the necessary spin to the projectile and is very similar to that now used. The cylindrical surface of the projectile was cased with lead, which as the shot moved along the bore was forced into the rifling which imparted the

ORDNANCE AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED, ENGINEERS, NEWCASTLE-ON-TYNE.

Fig. 10. Breech End of "No. 1 Gun."

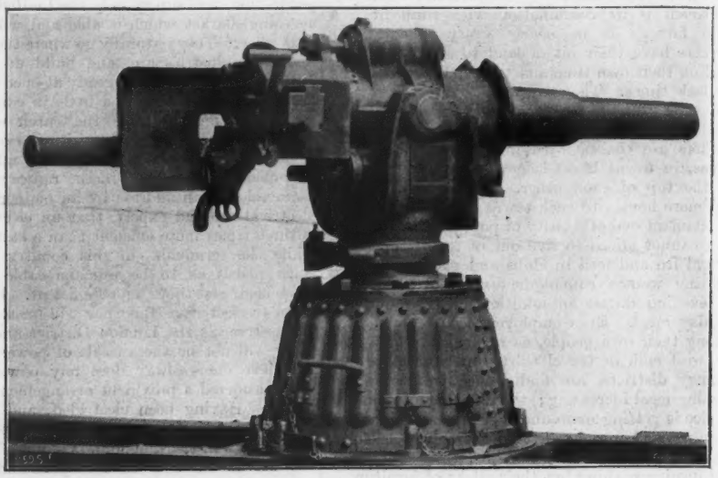


Fig. 11. Breech End of 6-Pounder Tank Gun.

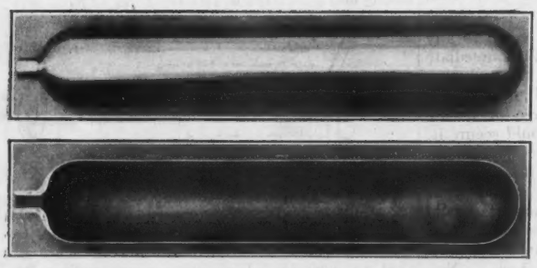


Fig. 12. "Vibrac" Steel Oxygen Flask.

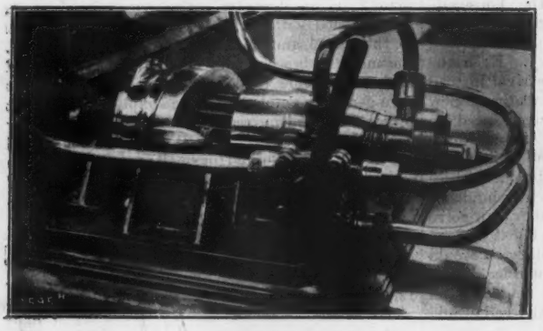


Fig. 13. Swash Plate Engine for Gun Mountings.

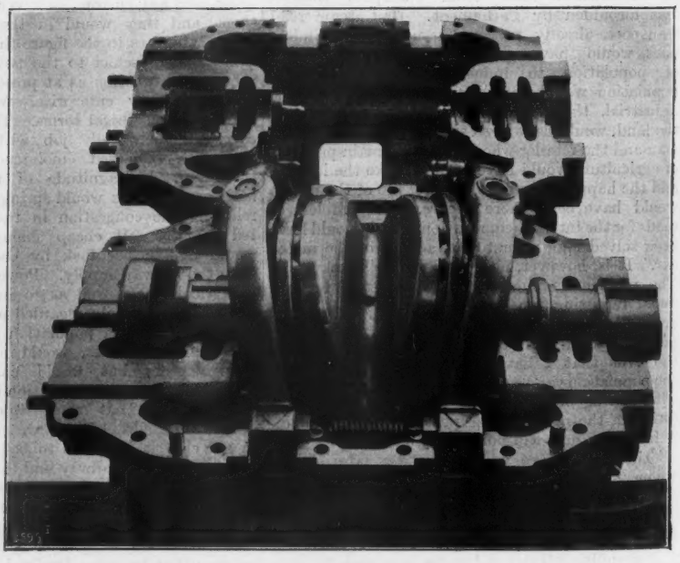


Fig. 14. Double-ended Mechanism of Swash Plate Engine.

rotation required. The gun gave excellent results, the range and accuracy far surpassing all previous types of ordnance. The lead casing on the projectile, although eminently satisfactory for the purpose for which it was intended, sometimes stripped while the projectile was in flight, and became a source of danger to the infantry who were in front. The copper driving bands now fitted on the bases of projectiles were not introduced until many years later. "No. 1 gun" thus was a very important departure and the type proved of great use at the time. For some reason, which is now difficult to understand, muzzle loaders were later reverted to, and it was not until the 'eighties that the breech loader was again adopted. Fig. 10 shows the breech end of the gun and the elevating gear with which it is fitted.

Next to it, and useful as indicating the progress in ordnance over a period of nearly seventy years, is a 4½-in. howitzer firing a projectile of 35 lb. with a muzzle velocity of 1,450-f.s. The length of bore is 90 in., and the weight of the howitzer is nearly 15 cwt. It has a nickel steel barrel wound with steel ribbon to strengthen it. The breech block is of the interrupted screw type, mounted in a carrier hinged to the breech end, and one movement of a lever is sufficient to turn the block and open the breech. No. 1 gun had no special recoil arrangement fitted; that of the howitzer is on the pneumatic principle, in which a piston during the recoil forces liquid out of one cylinder through a valve into a second charged with compressed air, whose pressure is further increased, so that the energy of recoil is thus absorbed and used to run out the weapon after recoil. The cylinders are placed immediately below the howitzer.

A third type of artillery is shown in a short six-pounder tank gun, weighing about 5 cwt. The breech block mechanism is different from the howitzer in being of the type in which the block slides in a transverse direction (see Fig. 11). The three weapons are an interesting study, not only in breech mechanisms, but also in the methods and devices used for elevating and depressing and in sighting.

The exhibits already referred to represent that branch of the firm's activities which is principally connected with the Armstrong or Elswick side, but there are others and amongst these must be noticed two which appertain to Whitworth and the Openshaw works. Whitworth, to whom we are primarily indebted for those methods and instruments of precision which rendered scientific engineering possible, was also a leading metallurgist, and his

researches and investigations resulted in a great improvement in the qualities of British steel, and especially that for armour and gun construction. Precision instruments made by the firm are on view, and there are also exhibits in which an improved type of steel is employed, indicating that Whitworth's work has been steadily and successfully continued.

The steel referred to is named "Vibrac" and has as a constituent, molybdenum. It is produced in the acid open-hearth furnace and has an ultimate tensile strength of 61 tons, a yield point of about 47 tons and an elongation of 8¼ per cent. in 2 in., compared with 46 and 34 tons and 17 per cent. elongation obtained with nickel steels hitherto used in gun construction. It is claimed the new and stronger material is just as readily forged and heat treated, more easily machined and more uniformly hardened than nickel or chrome steels. Moreover, the material is less liable to distortion and stressing during the various operations of gun making, gives better and more uniform results under impact tests, and is more suitable for purposes in which high stresses and sudden shocks are experienced.

In addition to its employment in gun construction it has been used for other purposes. A large forging of this material, intended for the rotor of a steam turbine, is exhibited, as also are various portions of lathes and other shop machines. One recent and interesting application of the material is for the oxygen flasks supplied by the company to the latest Mount Everest expedition. It was necessary the flasks should be as light as possible and at the same time contain the maximum amount of the gas. A strong and homogenous material, capable of being easily forged, welded and machined was therefore necessary, and Vibrac was employed. Several of the flasks which have been tested are on view. They are about 4 in. diameter and 2 ft. long and weigh, when empty, 6 lb. Each was tested to 2,750 lb. per square inch by air pressure, and one tested to destruction withstood 4,200 lb. per square inch before bursting. Tested by hydraulic pressure the elastic limit was reached at 1·4 tons per square inch and the bursting pressure at 1·83. A bullet fired at another bottle passed through without cracking or splintering. Another charged to 1,500 lb. per square inch was placed under a weight of 88 lb. which had fallen through 30 ft. and, although flattened, remained tight. Sections of a flask cut through longitudinally are exhibited and illustrate the uniform thickness of the material and the high quality of the welding. The outside surface shows that the material is one which is easily machined. The flasks are illustrated in Fig. 12.

With the limits to displacement of capital ships and aircraft carriers imposed by the Washington Treaty, and with rumours of another conference to discuss limits to other types of warship, any economy in weight which can be secured in one direction can be utilised to improve the offensive or defensive or other qualities of the vessels. There are many uses to which a material such as Vibrac can be put in warships and thereby a saving in weight effected. Guns have already been referred to, but it appears practicable to extend its use to torpedoes, air bottles, gas flasks and similar fittings subjected to high pressures and stresses.

Another exhibit is the Armstrong swash-plate "engine," which is extensively used for gun-mountings and is also being adopted for steering, capstan and winch installations. A working model is on view (Fig. 13), which shows that it embodies the same general principle, somewhat differently applied, as the Williams-Janney speed gear described in Article II. In the model, fourteen small pistons work in cylinders drilled axially in a fixed circular plate concentric with the shaft. The ends of the piston rods are secured to an inclined circular disc, which cannot rotate but which is fitted with two trunnions, which slide in two horizontal slots at the opposite side of the casing. Bearing against its back is a cast member keyed to the shaft. Water from a hydraulic pump is led to a port at the cylinder end of the shaft and the rotation of the latter with the supply port, causes the pistons to be forced in and out, giving a curious motion to the inclined plate and resulting in a rotary motion of the casting bearing against it and thereby the shaft. A discharge pipe leading from a rotating port serves as a return for the water to the hydraulic pump. The mechanism, when used as a hydraulic motor, is double-ended, two inclined plates being fitted at the middle (see Fig. 14).

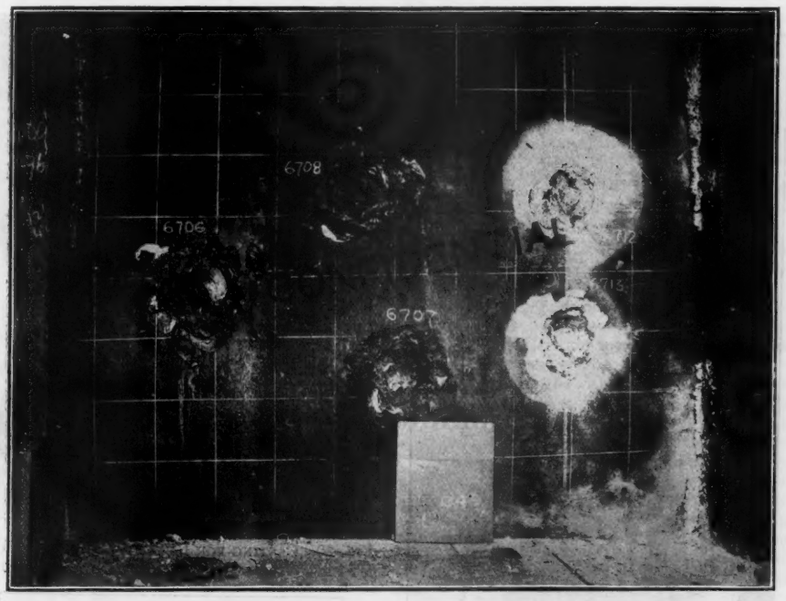


FIG. 15. BEARDMORE 9-IN. ARMOUR PLATE AFTER TRIAL.

As is well known Messrs. Armstrong have built a very great number of warships of all sizes and types, but space can evidently only be found on the stand for a model of one of these, the super-Dreadnought Malaya, a very suitable model for an Empire exhibition as she was presented to the Government by the Malay States. The ship was ordered in 1913 and completed in February, 1916. Of the Queen Elizabeth class, she is 600 ft. in length with a beam of 90½ ft. and a draught of 28¾ ft., giving a displacement of 27,500 tons. Her speed is 25 knots with the engines developing 75,000 shaft horse-power. Her main armament consists of eight 15-in. guns in twin turrets, two forward and two aft, one pair at each end being super-imposed over the other pair. The secondary armament is made up of fourteen 6-in., two 3-in. anti-aircraft, and some lighter guns, the torpedo armament being four 21-in. submerged tubes. The belt armour is 13 in. thick. This class of capital ship was the first to carry oil fuel only, previous vessels carrying both coal and oil. The total quantity of oil which can be carried is 3,400 tons. Amongst other models of ships built by the firm is one of an ice breaker, and another of an exceedingly finely moulded yacht—the Erthogroal—built for the Sultan of Turkey in 1905. With a displacement of 900 tons she attained a speed of 20 knots on trial.

Another interesting exhibit is a model of the naval airship R33, sister vessel to R34. She was designed by the Admiralty in 1916 and was a modification in some important respects of a German Zeppelin which came down at Wigborough, Essex, after being damaged by a projectile from an anti-aircraft gun. R33 was erected at Messrs. Armstrong's airship shed near Selby, the girders and other details being assembled at Elswick. Five airships—R25, 29, 33, 35 and 39—were ordered from the firm, the first three were completed and the other two cancelled after the Armistice. R33 is still in existence in one of the Air Ministry's sheds, and will probably be reconditioned for the research work recently approved by the Cabinet. She has a length of 640 ft., a diameter of 79 ft. and a volume of 2,000,000 cub. ft. Five engines are installed each of 350 h.p. giving a maximum speed of 55 miles per hour. The Government Airship Scheme, recently announced in Parliament, includes the building of two airships of 5,000,000 cub. ft. capacity each. If of similar shape to R33 these vessels would be 870 ft. long and 107 ft. diameter. Some idea of the bulk of such a vessel is conveyed by its displacement if submerged in salt water, which would be 143,000 tons or three and a-half times that of the Hood and nearly twice the latter's total volume.

Between the spaces allocated to Mesars. Vickers and Armstrong is that of Messrs. Beardmore, which in variety of exhibits is a worthy rival of the two other firms. Their warship construction is represented by a model of the Benbow, which was completed in October, 1914. One of the Iron Duke class, she is 580 ft. in length, 90 ft. beam, 28 ft. mean draught and displaces 25,000 tons. With engines of 29,000 shaft horse-power, she attained a speed of 21½ knots. The main armament is five pairs of 13·5-in. guns, two forward and two aft, and one pair amidships, whilst the secondary armament includes twelve 6-in. guns. Four 21-in. submerged torpedo tubes are fitted. The belt armour is 12 in. thick and that protecting the barbettes 11 in. The 6-in. guns are placed in a battery on the upper deck and protected by 6-in. armour, a system followed in the Queen Elizabeth class—the next after the Iron Duke class. Benbow and her sister vessels were the last British capital ships arranged to carry coal and oil fuel. Of the former 3,250 tons and of the latter 1,050 tons can be stowed. The Ramillies, of the Royal Sovereign class, is a later capital ship built by the firm and completed in September, 1917. Lack of space has prevented her model being included.

Messrs. Beardmore did not commence the manufacture of armour until some time after other firms, but soon proved their capabilities in this important branch of armaments. They exhibit two samples of armour manufactured by them, one a 4-in. communication tube and the other a plate of a maximum thickness of 9 in. but diminishing at the top to about 3 in. Both have been tested by firing projectiles at them. The plate was proved with 9·2 and 12-in. projectiles, the smaller calibre being fired at the portion at which the thickness was 6 in. and the larger projectile, at the thickest part of the plate. Both sizes of projectile were of the armour piercing capped type. The striking velocity of both sizes was from 1,340 to 1,400 ft. per second. The damage inflicted on the face of the armour, even from the 12-in. capped shot, appears trifling (Fig. 15). The photograph reproduced is no longer "confidential." The material of the plate in the vicinity of the damage is well worth inspection, as it indicates the extreme hardness of face which has been secured by the treatment to which the steel has been subjected. The tube was

THE NAVY AT THE BRITISH EMPIRE EXHIBITION.

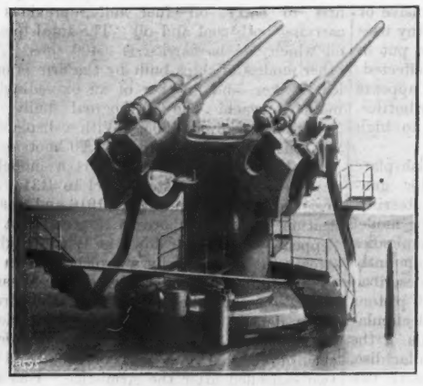


Fig. 16.

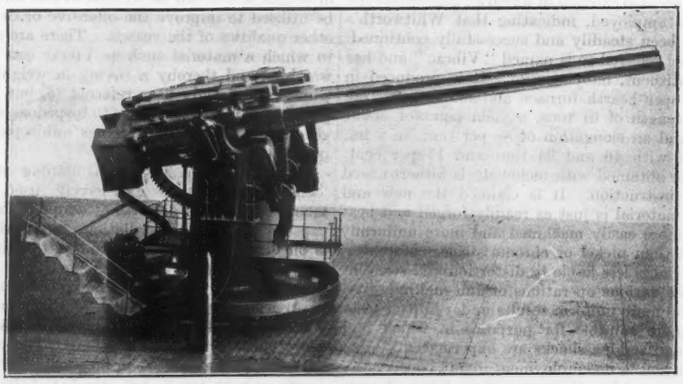


Fig. 17.

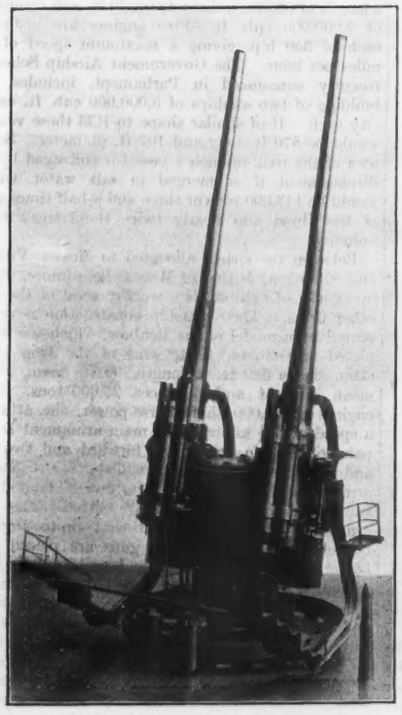


Fig. 18.

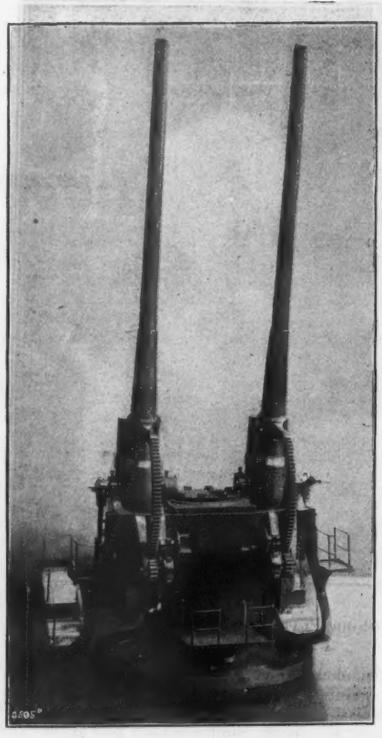


Fig. 19.

Figs. 16 to 19. 4-In. High-Angle Guns on Twin Mountings; Messrs. William Beardmore and Co., Limited.

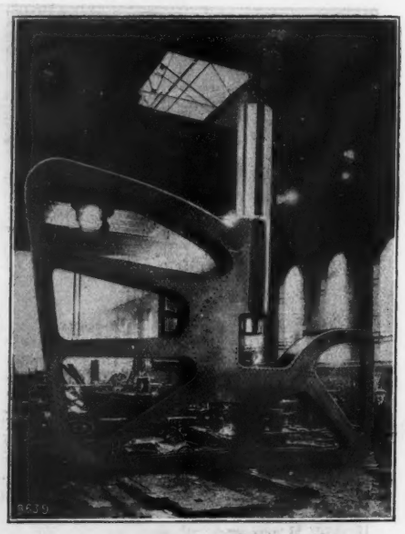


Fig. 20. Casting for Rudder for H.M.S. Hood; Messrs. William Beardmore and Co., Limited.

Fig. 21. Model of 21-In. Capped Projectile Messrs. Hadfields, Limited.

tested with 6-in armour piercing capped shell with striking velocities of from 1,230 ft. to 1,525 ft. per second and successfully withstood the tests.

The activities of Messrs. Beardmore on the ordnance side are extensive and varied. During the war the output was no less than 5,000 guns and howitzers. One exhibit is the worn inner A tube of a 15-in. naval gun such as is mounted in the Queen Elizabeth class of capital ships. This tube was removed from the gun and replaced by another constructed and machined by the firm, a striking example of their work in gun construction.

Another model shows a mounting for a pair of 4-in. guns which are intended for use against aircraft (Figs. 16 to 19). The guns are separately operated and can be elevated to the vertical or even to 10 deg. beyond. The two are trained together around the central pedestal. They are 55 calibres in length, and fire a projectile of 25 lb. with a muzzle velocity of 3,200 ft. per second, an appreciable higher velocity than that of ordinary guns. A 12-pounder field gun is also exhibited, and is fitted with a special recuperating device on its recoil system which has been designed by the firm and gives good results on trial, 15,000 rounds having been fired without the least sign of any defect. Machine guns of various types and sizes are also on view.

The naval airship R.34, which made the voyage to and from the United States in 1919, is represented by her model. This vessel, which was a sister ship of R.33, the particulars of which have been given above, was erected by Messrs. Beardmore at the airship shed at Inchinnan on the south side of the Clyde and about two miles from their shipbuilding works at Dalmuir. The major portion of the girder work and other details was completed at the shipyard and transported to the shed. R.24, R.27 and R.36 were other airships built by the firm during the war. Of the four only one, R.36 remains, R.33 having been wrecked, fortunately without loss of life, in 1921, and the other two dismantled after service, to make room for later and improved

types. R.36 was completed for commercial purposes, but has not been so used. She is 33 ft. longer than R.34 and has 140,000 cub. ft. greater capacity. Due to the policy—or lack of policy—on the part of successive Governments in connection with rigid airships, the erecting shed at Inchinnan has since been partially dismantled.

Parkhead Forge is the establishment at which the major portion of Messrs. Beardmore's steel work is carried out, and here a great number of the largest steel castings used in the construction of British warships have been produced. Several models of these castings are exhibited, one of these representing the rudder of H.M.S. Hood (Fig. 20). This steel casting was 26 ft. long and 25 ft. high, its weight being about 45 tons. It was transported along the public roads for the nine miles between Parkhead and Clydebank, where the vessel was built. Three engines were required for hauling it, and the journey had to be started after midnight when the trams had stopped and the roads were clear.

Opposite to Messrs. Beardmore's space is the exhibit of Messrs. Hadfields, the famous steel makers of Sheffield. Amongst many other items of war material are shown specimens of various types and sizes of projectiles used in naval and other guns, many of these being of the capped variety used for the attack of armour. Amongst the capped projectiles is a model of one standing about 8 ft. high and of which an actual shell would weigh two and a-half tons. The calibre is 21 in. (Fig. 21). The muzzle energy of such a shell is 250,000 ft.-tons or approximately 2½ times that of the 16-in. and three times that of the 15-in. projectile. It would penetrate 30 in. of hard armour at a range of 10 miles. But for the Washington Conference it is quite probable guns firing such projectiles would have been mounted in the largest warships. The firm also exhibit gun shields and armour plates made of their celebrated "Era" steel. One of the shields is shown on a 6-in. gun, a mounting for which it was intended, and has been severely tested by the British Government, at their proving ground, under the attack of 6-in. common and lyddite shell which produced little effect even at high velocities; also under the attack of 6-in. capped armour-piercing projectile. The shield, and also the cast steel armour plate, show how well the "Era" steel has withstood the severe firing tests.

Messrs. John Brown and Co., Limited, of Clydebank and Sheffield, are represented by a very modest exhibit which includes models of two of the many warships built by them, the Repulse and the Ceres. The former with the Renown, built by the Fairfield Company, were the last capital ships ordered by Lord Fisher when First Sea Lord, and who in a letter to Sir Eustace d'Eyncourt, dated December 19, 1914, referred to them as the Rhadamanthus design.* They were ordered as a sequel to the successful part taken by the Invincible class—recommended to be built by Lord Fisher's Design Committee in 1906—in the Battle of the Falkland Islands, which had taken place eight days before the date of the letter referred to. Laid down on Lord Fisher's birthday—January 25, 1915—the Repulse was completed in August, 1916, a fine record for building a ship of a displacement of 26,500 tons. As built, the vessel was 794 ft. long 90 ft. beam and 25½ ft. draught. With engines giving a shaft horse-power of 112,000 a speed of 32 knots was obtained. The normal amount of oil carried is 1,000 tons, but over 4,000 can be stowed. Three pairs of 15-in. guns are carried, two pairs forward and one pair aft. The secondary armament consists of seventeen 4-in. guns, of which 15 are mounted in five triple turrets. The belt armour is 6 in. thick continued between main and forecastle decks by a 1½-in. thickness. The barbette armour is 7 in. thick. The firm also built the Hood, the capital ship which embodies the experience gained in the war, and which so long as the Washington Treaty is in force will remain the largest capital ship in the world.

The Ceres, represented by the other model, is a light cruiser ordered in April, 1916, and completed in June, 1917. Of 4,200 tons displacement, the length is 450 ft., beam 43½ and draught 14 ft. A speed of 29 knots was obtained with the engines developing 40,000 shaft horse-power. The armament consists of five 6-in. guns all on the middle line, three being mounted on the forecastle deck, one forward, one amidships and one aft. The last-mentioned fires over a similar gun mounted on the upper deck aft, whilst the fifth is on the forward superstructure firing over the foremost gun on the forecastle. Four 21-in. twin revolving torpedo tubes are fitted at the sides on the upper deck. The sides of the vessel are fitted with 2 in. of protective plating secured to a 1-in. thickness of steel.

Messrs. Cammell Laird and Co., Limited, perhaps one of the oldest of our great shipbuilding firms, and the builders of many famous warships, have no exhibits which are of interest from the naval point of view. They are now busily engaged in the construction of the battleship Rodney, a design which is too recent to be exhibited in model form. They show pictures of some of the fine merchant ships constructed at their Birkenhead works, but most of their space is allotted to various exhibits of railway material, a branch of engineering which is also a feature of all the shipbuilding firms which have been mentioned.

* This letter was reprinted on page 709 of our issue of May 30.

LITERATURE.

The Modern Soap and Detergent Industry, including Glycerol Manufacture. By Geoffrey Martin, D.Sc., Ph.D., F.I.C. In three volumes. Vol. I.—Theory and Practice of Soapmaking. London: Crosby, Lockwood and Son, 1924. [Price 36s.]

This is a portentous work. Three volumes will be required for its completion, of which we see only the first. The outlook of the author or compiler is wide, and his ambition far-reaching, for he aims at producing a more complete work on soap than any that has yet been published at home or abroad, and one that shall record all recent discoveries and progress. The fulfilment of this aim will certainly produce a big book, whether it will produce an edifying one will be better determined when the whole scheme has been presented. To collect the details of patents, whether successful or unsuccessful, to extract the researches of experts from technical journals, to summarise the experiments of chemists and to repeat the arguments of recognised authorities, demands very considerable industry. The power of the master, however, is shown in discriminating selection, in careful sifting and criticism, and the exercise of sound judgment. These qualities are not too conspicuous in this instalment. The facts are all there, no doubt; the collection and arrangement must have demanded much time and entailed enormous labour, and to the energy exhibited we should wish to do justice. But we are not sure whether Dr. Martin intended that the work should be regarded as a book of reference, to be consulted on emergency, or as a book to be read from cover to cover. If the former, it has not the terseness and convenience of an encyclopedia; if the latter, the want of arrangement and consecutiveness is forbidding. Of one matter, slight but important in a work of reference, we can speak without hesitation. The pagination is inconvenient and annoying. In this first volume there are seven sections, varying in length from perhaps a dozen to a hundred pages, and each section begins at page 1. This want of continuity is the more irritating because no indication is provided to show the section in which one is reading, and if reference is made to another section one may turn all over the book to find the particular one required. No index to this volume is attempted, and the construction of an adequate index that will give the volume, the section and the page of that section will be a matter of no small difficulty, but it will have to be accomplished, for such a book unindexed would be almost valueless from a practical point of view.

Having expressed some disapproval of the general arrangement we may turn with the greater pleasure to the contents, and in the first place ask whether the work was worth doing, whether the time and labour were justified. The answer must be in the affirmative, though many well-known works—of which perhaps that of Dr. Lewkowitsch is the most prominent—cover much of the same ground, have received the criticism of many experts and become acknowledged classics. It is necessary, therefore, to see what precise position the book hopes to occupy in the literature of technology. It evidently aims at addressing a smaller class than is contemplated in the preparation of such works as those referred to, but to put that class in possession of every detail that can be of service. The contributors to learned societies and technical journals do not regard themselves as speaking to a small and select audience, but hope that their work may reach and benefit the whole industry, that it will be tested and criticised, and made the means of further improvement. Anyone who assists in the dissemination of a knowledge of carefully-prepared memoirs and descriptions of researches is doing good work, and the author, by bringing scattered, or it may be forgotten, facts before a wider public, facilitates fresh inquiries and suggests further experiments. We believe that the spread of accurate and tested facts is likely to fructify. Dr. Martin, however, in his preface takes another, but perhaps equally defensible, view. After remarking that great technical successes have been preceded by a long series of failures on somewhat similar lines, he decides that the ventilation of impracticable processes is justifiable, because the failure of the original proposer may suggest to the technologist new ideas and new methods that will lead to commercial success. For this reason he proposes to discuss, presumably in future volumes, the use of other detergents than soap. A fortunate discovery may find some material—mineral or organic—that will surpass the salts of fatty acids in detergent power, and he considers that it is to some lucky accident, the consequences possibly of past failures, that we must look for the future development of the cleansing industry.

In estimating the direction of future development the author bases his views on the possible shortage of fat in the near future, owing to the increase of population and the imperative demand that will arise to reserve this valuable product for more urgent purposes than soap manufacture. The chemist, compelled to find substitutes, may look to petroleum and hydrocarbon oils to supply the deficiency, and the next great chemical achievement affecting the production of fatty acids may result from experiments on petroleum. This is an interesting suggestion, but we should doubt if it is well founded. The chemical treatment of the hydrocarbons of petroleum oils have hitherto given more trouble than profit, and if the chemist's ingenuity is successful the scheme may not be economically possible. While fats are constantly being renewed, and the supply of vegetable and fish oils that can be converted into hardened fat by catalytic hydrogenation is practically inexhaustible, the quantity of petroleum from the oil fields is strictly limited, and there are not wanting signs that a large proportion of the natural store is exhausted. There are hydrocarbons which might be recovered from waste products, and these may constitute the sources upon which Dr. Martin is inclined to rely. To convert these into fatty acids and glycerides, however, presents great difficulties from the chemical side, though in war time the Germans claimed that methods they adopted in similar processes proved successful.

There are, as already said, seven sections dealing more or less closely with the materials used in soap making, and with the methods of use. The number of oils and fats at the command of the manufacturer has greatly increased, while the scenting of soaps by perfumes, synthetic and natural, has become an art to be followed by an expert. In fact, the soap-making industry has undergone a complete revolution, and old-fashioned household soaps have to a large extent, like the famous mottled soap once so popular, given place to more approved oil soaps, with a large proportion of rosin. Into the commercial and technical details we have no intention of entering, but in the large mass of collected materials many interesting points connected with phenomena are raised that come under daily observation and, notwithstanding, have successfully resisted all attempts at complete

explanation. For instance, the practical value of soap lies in its detergent action, and yet we are unable to say in which of the chemical or physical characteristics lies this peculiar quality. The author dismisses as many hypotheses as he sets up, and it is difficult to see which way victory lies on the stricken field. We think, however, that all disputants will allow that for soap or similar compound to have cleansing properties, an acid soap and a free alkali must be present. The action of colloidal clays and similar detergents is probably mechanical. The soap may have the power of emulsifying the greasy matter, the usual accompaniment of dirt, while the formation of a foam-like lather capable of entangling dirt particles is a factor of some importance to many writers. Then there are rather fanciful hypotheses such as the formation of adsorption compounds, and action akin to Brownian movement causing the movement of minute particles. There are many other suggestions from which the curious may make a choice, but we believe the untrained and unsophisticated will insist that friction, vigorous friction, and heat are necessary. Advertisements may and do state that if their soap is used no labour is required, but those who use the soap are inclined to look upon this assertion as a kindly sophism.

The second difficulty for which we should like to ask an explanation is wherein lies the lathering power. Experiment has taught us how to produce a soap that will or will not lather, but the reasons are hard to seek. Emulsification plays a part, as seen in stirring oil and water vigorously together, and the small spherical particles are seen to coalesce. But surface tension supplies another clue, for it is known definitely that when surface tension exceeds a precise number of dynes per centimetre all lathering ceases. Here the work of Willard Gibbs comes to our assistance, and we are able to penetrate this mystery a little further, for we can measure the surface tension of soap solutions and predict their behaviour. With sodium myristate, for some reason, we have the maximum lowering of surface tension, while hardened whale and fish oils give very poor material for soap making. Other authorities insist that the difference of behaviour between castor oil soaps and cocoanut oil soaps is explained by the relations of these oils towards electrolytes. But such an explanation is purely experimental, and advances the inquiry very little further. The reference to these two enigmas shows that many interesting subjects are discussed in this volume, to more of which we would refer if space permitted.

Oil Engines. By A. L. [Bird, M.A., [A.M.Inst.C.E. London: Methuen & Co. [Price 12*s.* 6*d.* net.].

The engineering advances of recent years render the task of the technical author one of increasing difficulty. From the purely business point of view a book is required to suit a large number of readers, while modern training makes it natural for the engineer to pursue a highly specialised course of study. Again, the same advances preclude the inclusion of a long section dealing with the elementary foundations of the work if the volume is to be of reasonable size. This inevitably means that the abilities of the author, as instructor, are more severely tested than ever before, partly due to the difficulty of most advantageously selecting material for treatment from the mass of it at his disposal. Such difficulties are well known to many writers but, unfortunately, are appreciated sufficiently only by a minority of them. Mr. Bird, however, belongs to this minority. He omits elementary material on heat engines which might possibly have occupied quite one-third of his three hundred pages, yet makes demands of the lightest description on the readers' previous knowledge. The work is modern and not lacking in originality. It is described as suitable for both university students and practical engineers. This phrase has found great favour in recent years, doubtless as a stimulant to sales, but since the best engineers are usually produced by a sound practical training, after college work, it is obviously quite impossible for a book of the type under discussion to suit such men during both periods of their work. Nevertheless Mr. Bird's primary object of instructing engineering students is admirably fulfilled.

The mathematical development of the subject, covering barely twenty pages altogether, is really good. This was to be expected of a Cambridge writer, but what is distinctive is the fact that the matter is quite readable by a student of evening school attainments in the calculus. One or two errors occur in the working, which, however, are not likely to mislead the careful reader. There are numerous references to original papers, which latter those specially interested should read. The W. J. Walker references are worthy of the attention given to them in the book in view of the reliability of the results of this worker.

In Chapter I a distinction is made between the Diesel, hot bulb, and injection types of "heavy" oil engines, which practical engineers will consider a little academic. Chapter II, headed "Cycles of Operation," commences with the deduction of a cumbrous general formula for the efficiency of a "combination" cycle, which has the advantage, however, of being readily adapted to the two special cases of the gas and Diesel engine. A graph supplied considerably assists in using the data. Up to this point the hypothesis of constant specific heat is utilised. The internal energy of a gas in an engine cylinder is discussed with the aid of an original curve. In this graph ordinates represent internal energy and abscissæ represent temperatures. The slope of the curve at any point gives the specific heat at that point from which R, the gas constant, and γ, the ratio of the specific heat at constant pressure to that at constant volume, may be deduced. Tables are given for conditions before and after fuel injection, followed by a good introduction to the theory of variable specific heats. Examples on flame temperature, and the Hopkinson method of calculating the true theoretical efficiency for gas engines, are fully worked out in the text. A practical consideration of the cycles in a real engine, with some illustrative timing diagrams, follow, and concluded the chapter. The logical development of the book would have been enhanced if this chapter had followed the succeeding one, Chapter III.

This latter section is devoted to a consideration of oil fuel and combustion, and contains some of the graphical formulæ of chemistry, upset by the printer in one instance. It is, however, one of the most satisfactory chapters of its kind we have read, containing the desirable worked example, tables, and information, with efficient economy of space. Still, an important point must not be overlooked regarding heavy oils. Owing to the very rapid and extensive increase of refining plant to-day, especially in America, economy in the near future will not require the use of the lowest grade oils.

"Charging the cylinder" is the subject of Chapter IV, and its fundamental importance is realised by the author. The method of treating the speed of entering air is valuable. It depends on the approximation $v = \sqrt{2gh}$, where h is the "head" of air. This is then used in conjunction with the usual time-area diagram. An original treatment is offered in dealing with "scavenging," based on the principle of dynamic similarity. One meets this principle now-a-days variously applied to problems in hydraulics, aviation and chemistry. The large diagrams in this part of the treatise greatly facilitate the following of the text.

Chapter V is the most important one in the book; it is on injection and ignition of the fuel. Eleven different arrangements for treatment are first classified, and the methods in use in each case are described in detail, with the aid of practical drawings. This large number of arrangements arises from the fact that the book undertakes to treat Diesel modifications, as well as the standard types. In connection with the comparison of solid with air injection, a detailed piece of analysis is carried out. Using the results of H. S. Allen, Millikan and Stokes, together with the mechanical ideas on resisted motion, the study of atomised oil drops is satisfactorily completed. The chapter concludes with notes on flame injection and ignition of refractory fuels.

Chapter VI is a short summary of available data for the comparison of the performance of engines, in order to estimate their efficiency. The effects of varying both load and speed are indicated. On page 169 the performances of different engines, tabulated in such a manner as to show at a glance the important results, should prove a most practical addition.

Chapter VII is on mechanical details peculiar to oil engines. An abbreviated sketch of the principles of design is attempted which will form an excellent introduction for the student to the works specialising in this field. A new geometrical construction is given for the finding of the acceleration of the injection valve lift, and it deserves to become popular from its simplicity. Pumps and air compressors are treated in a satisfactory manner, while notes on intercoolers, controls, engine reversing, and Gumbel's construction for critical speeds complete the section. Chapter VIII deals with the application and development of engines using oil fuel, and contains a number of large-size plate-diagrams, very suitable for the drawing-office. The claims of transport, locomotives, and ships on these agents are not exaggerated. Latest tendencies are mentioned, and a useful index completes the book.

Summarising, the student will be much the better for a study of the volume, while many practical engineers will find therein a good compensation for their lack of a sound early training.

THE COLLIERY AT THE BRITISH EMPIRE EXHIBITION.

(*Continued from page* 160).

Although electric transmission has the advantage of a greater radius of application for the same loss than other systems, the use of its predecessor, compressed air, has by no means ceased, and for many purposes it still finds much favour in mines on account of the special advantage it possesses of increasing the ventilation, particularly in clearing the workings where blasting operations are performed, and because any damage to the conduits can only result in loss of air pressure and leakage. In the mine at Wembley there are two examples of air compressors, one a fixed permanent plant on the surface, and the other a small self-contained plant, capable of being installed temporarily at any convenient distance from the pit. Not only is compressed air considered by many to be the most suitable means of driving percussive drills, but improvements in small turbines have rendered its use more practical than heretofore for driving coal cutters and conveyors. In the case of various types of coal-cutting machine that have been designed, the compressed air drive is interchangeable with the electric drive, the actual gear in the cutting heads remaining the same for both kinds of power supply, and the joint between the driving and driven halves of the machine being so designed and constructed as to ensure interchangeability.

Installed in the surface buildings, there is a horizontal two-stage machine, capable of compressing 1,000 cubic feet of free air per minute at sea level to a pressure of 80 lb. per square inch. It was manufactured by Messrs. Walker Bros. (Wigan), Limited, of Pagefield Ironworks, Wigan, and is illustrated in Figs. 86 to 90 on pages 191 and 192.

The cylinders of the compressor are completely surrounded by water, the covers being also water-cooled. An inter-cooler, shown in Fig. 88, fitted with brass tubes with a view to increasing the efficiency, is fixed over the top of the engine for cooling the air on its passage from the low pressure to the high-pressure cylinder. The cylinder dimensions are: L.P., 20 in. diameter; H.P., 13 in. diameter; the stroke of the pistons being 18 in. in both cases; and the normal revolutions 180 per minute.

The air supply is drawn through a Visco air filter consisting of a screen filled with short pieces of small brass tube, placed outside the engine house, and ensuring a clean air supply at low initial temperature. The compressed air is delivered into a vertical receiver 4 ft. 6 in. diameter by 10 ft. high, constructed for a working pressure of 100 lb. per square inch by Messrs. H. and T. Danks (Netherton), Limited. The working parts of the compressor are totally enclosed and the main bearings, crank pins, crosshead pins, and slides are lubricated under pressure from a positively-driven pump operated by the engine. In order to ensure proper lubrication

AIR COMPRESSOR AT COLLIERY; EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. WALKER BROS. (WIGAN), LIMITED, WIGAN.

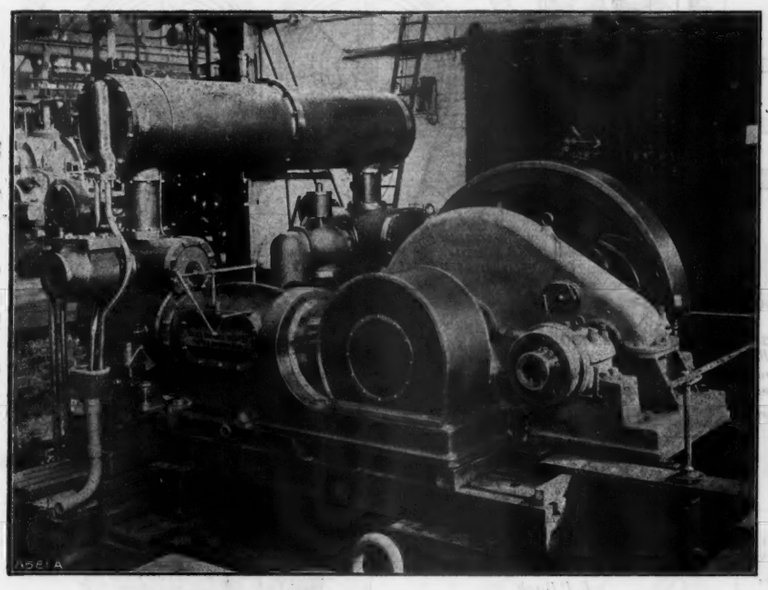
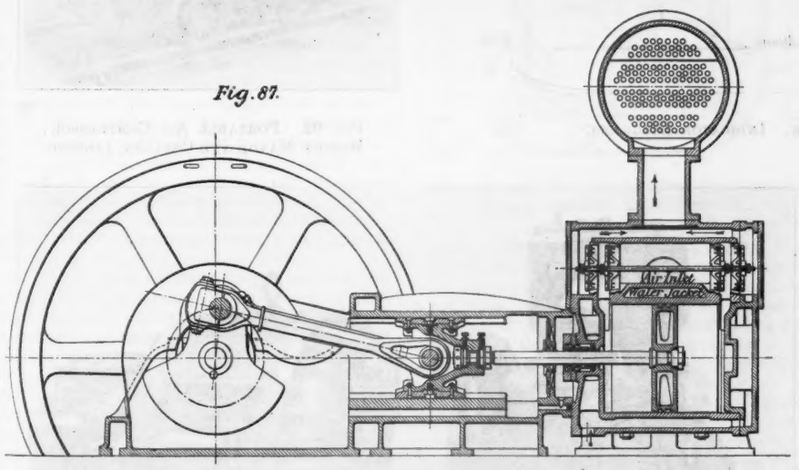
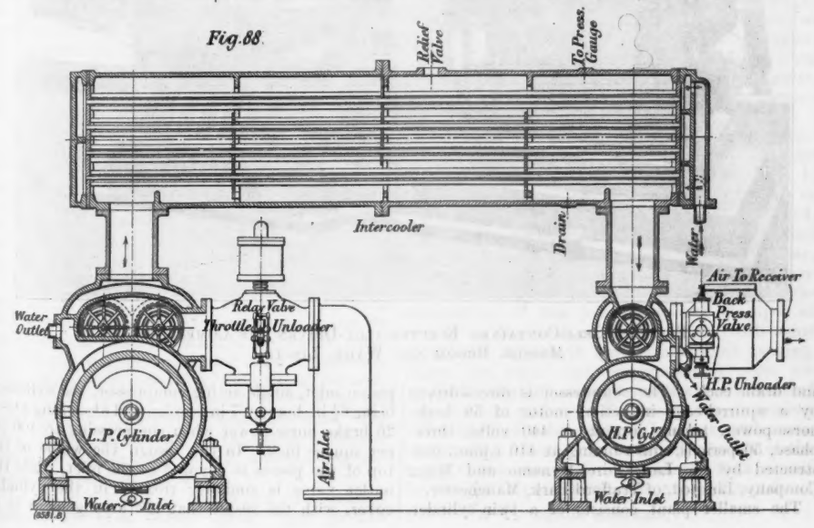


FIG. 86.





of the working parts before the engine is started, a novel feature in the use of forced lubrication has been introduced in the form of a hand-operated gear for the pump, by the use of which the lubrication of the working parts can be ensured before the compressor is set to work.

The compressor is driven at constant speed by an electric motor of 186 h.p. constructed by the English Electric Company. This motor is of the induction slip-ring type, constructed for 440 volt, three-phase, 50 cycle current, and running at a speed of 586 r.p.m., of which mention has been made in ENGINEERING (vol. cxvii), June 20, 1924, page 795. The equipment comprises a standard liquid starter and control pillar of the mining type, as well as an oscillating phase-advancer. The motor drives the compressor through a flexible coupling and a single reduction gear of the turbine type, constructed by Messrs. David Brown and Sons (Huddersfield) Ltd., shown in Fig. 86. The gear is completely enclosed and has forced lubrication.

The motor being constructed to run at constant speed and the gear being permanently in mesh, a special arrangement of valves has been provided in order to enable the supply of air to the compressor to be regulated in accordance with the demand, and thus to permit the motor to develop only so much power as is required for the demand. The valve-operating mechanism is worked in the following manner: on starting the compressor, the main valve of the unloader is closed by means of the hand wheel; after the set has reached its normal speed, the main valve is gradually opened, and the output of the compressor is controlled automatically by the valve gear, which makes use of a Walker relay valve. The working of the compressor may be easily understood by reference to the indicator diagrams (Fig. 91), in which two different conditions are shown. Diagrams numbered 1 are taken from the compressor at full load. In the diagrams numbered 2 the unloading gear is in operation, and the amount of air admitted to the compressor cylinders is practically nil. A back-pressure valve provided between the high pressure cylinder and the receiver closes when the engines are running unloaded, thus preventing the air from returning from the receiver into the ports of the high-pressure cylinder. The diagrams give evidence of the small amount of power wasted in the cylinders due to compression and expansion when running under no load.

The installation also contains a self-contained compressor plant, of the standard vertical type "D" twin cylinder, 7 in. by 7 in. by 8 in., with mechanically-operated suction valves, direct coupled to a 22 brake horse-power, 440-volt, three-phase, 50-cycle explosion and flame-proof motor, constructed by E. Brook, Limited, of Huddersfield. This compressor, which is illustrated in Fig. 93, was constructed by Messrs. Broom and Wade, Limited, of High Wycombe. It has a capacity of 130 cub. ft. of free air, compressed and delivered at a pressure of 100 lb. per square inch per minute, and runs at a normal speed of 420 r.p.m. The compressor has water-jacketed cylinders with water-jacketed heads; it is fitted with mechanically-operated poppet suction valves and plate-type delivery valves, and has forced lubrication to all bearings, including crank pins and gudgeon pins. The makers claim that by adopting the multi-cylinder form of construction they obtain a compression more nearly isothermal than adiabatic.

An inbye compressor for drilling shot holes, that is to say, a compressor designed for working underground at a distance from the shaft, and capable of being shifted from place to place, should under ideal conditions be as portable as a full tub of coal. It is with this object that the portable compressor, installed by Messrs. Mavor and Coulson, Limited of Glasgow, has been designed. The underframe, wheels, and brakes form an integral part of the design. The compressor is of the single-stage, double-acting type, having a capacity of 55 cub. ft. of free air per minute compressed to 70 lb. per square inch (at which the safety valve blows off), and running at 480 r.p.m. The compressor is water cooled, and the circulation is effected by a rotary gear pump, driven by chain from the crankshaft. The circulating water is contained in a tank forming

AIR COMPRESSORS AT THE COLLIERY AT THE BRITISH EMPIRE EXHIBITION.

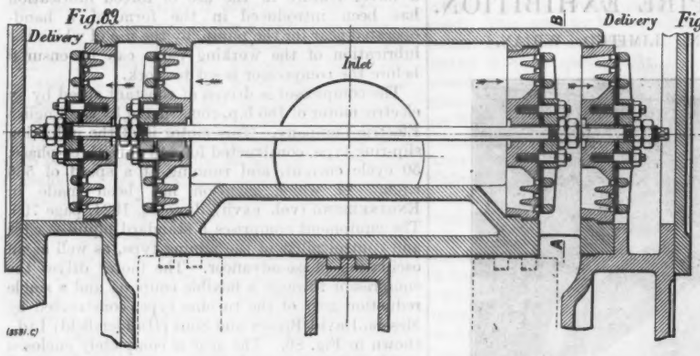


Fig. 89. Valves of Walker Air Compressor. Longitudinal Section.

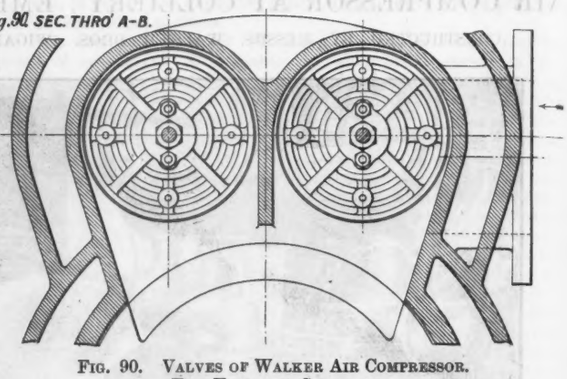


Fig. 90. Valves of Walker Air Compressor. End View and Section.

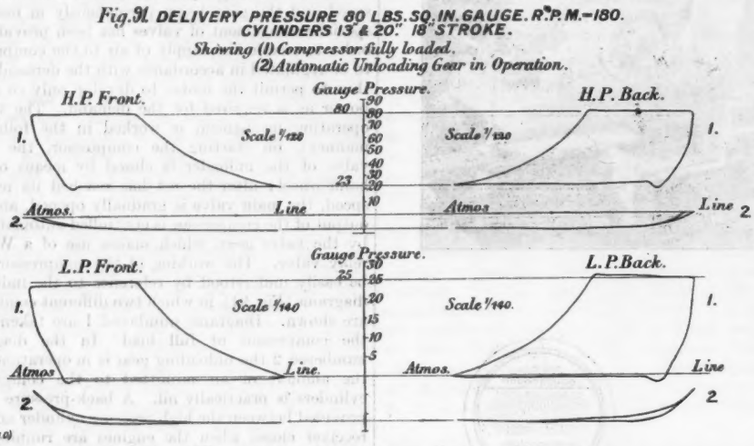


Fig. 91. Walker Air Compressor. Indicator Diagrams.

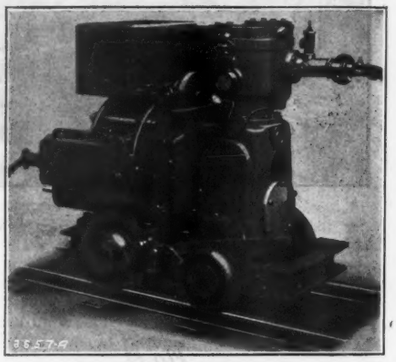


Fig. 92. Portable Air Compressor; Messrs. Mavor and Coulson, Limited.

part of the set, and the consumption is stated rarely to exceed 1 gallon per shift (Fig. 92). The ball bearings of the compressor are lubricated under pressure by means of an oil pump positively driven from the crankshaft. The capacity of the set is more than ample for one hammer drill of the size and type most frequently used at the coal face, and as such drills are usually intermittently used, it is found in practice that the compressor is frequently capable of supplying air for driving two drills.

The motor is of the totally-enclosed type, of the same size as fitted to the drive of the electric shaker conveyor, the stators of these three-phase motors being interchangeable. The motor is rated at 15 h.p., and the switch of the three-phase set, interchangeable with the shaker conveyor switch, is fitted as a component. A chamber formed on the crank-case, between the motor and the compressor, contains a case-hardened speed-reduction gear running in oil. A flange spigot registered on the end shield of the motor enables alinement to be retained independently of the outer structure. The flitting truck on which the set is mounted is fitted with wheels rotating on stationary axles. The weight of the whole outfit is just over 1 ton. The total height above the rails is 3 ft. 6 in., the length 3 ft. 10 in., and the width 2 ft. 4 in.

Messrs. Holman Bros., Limited, Camborne, exhibit two air compressors in the Palace of Engineering. The larger of these is a two-stage compressor having cylinders respectively 7½ in. and 12 in. diameter by 7 in. stroke, running at 380 r.p.m. and absorbing about 60 brake horse-power at the crank-shaft when compressing to 100 lb. per square inch. The machine is of the vertical, totally enclosed, double-acting type with forced lubrication to the crank-shaft journals, connecting rod ends and guides. The cranks are set at 180 deg., to ensure balance of the reciprocating parts. An intercooler of the multiple-tube type, with large cooling surface, is fitted in a cast iron body which carries the pressure gauge, safety valve, air cock and drain cock. The compressor is direct-driven by a squirrel-cage induction motor of 58 brake horse-power, taking current at 440 volts, three-phase, 50 periods, and running at 410 r.p.m., constructed by the Lancashire Dynamo and Motor Company, Limited, of Trafford Park, Manchester.

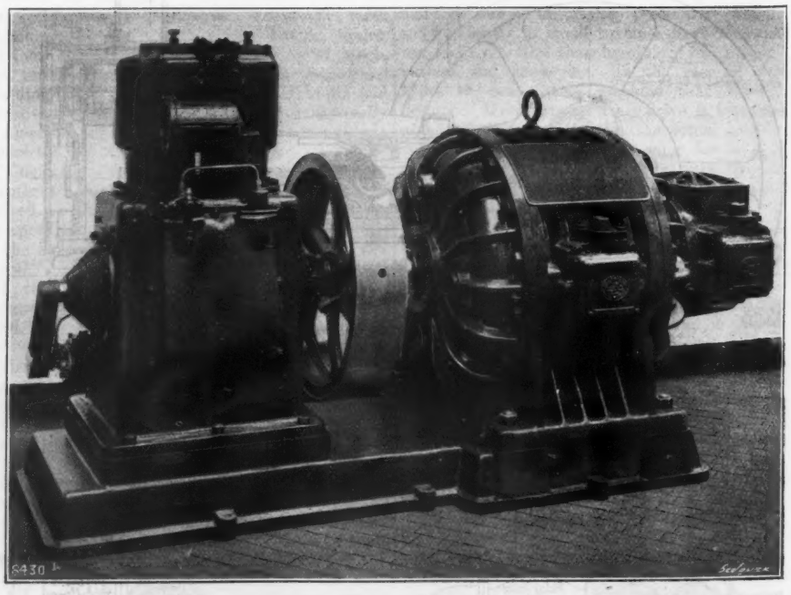


Fig. 93. Self-Contained Electrically-Driven Air Compressor; Messrs. Broom and Wade, Limited.

The smaller plant consists of a twin-cylinder, piston inlet, single-acting compressor, the cylinders being 6¾ in. bore by 7 in. stroke, and absorbing about 26 brake horse-power when compressing to 100 lb. per square inch. In this design the whole of the top of the piston is devoted to the inlet, while the outlet valve is similarly treated in the cylinder cover, with the result that the arrangement is in

THE COLLIERY AT THE BRITISH EMPIRE EXHIBITION.

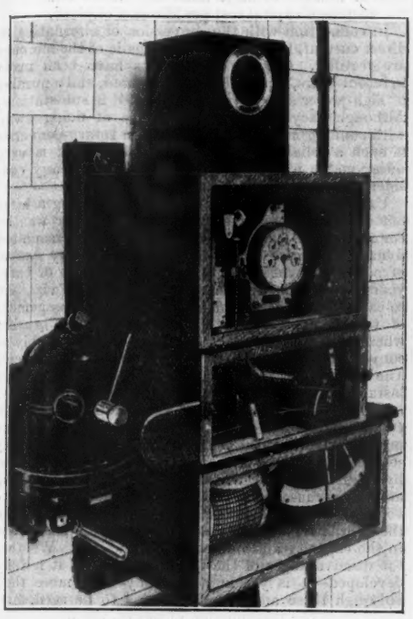
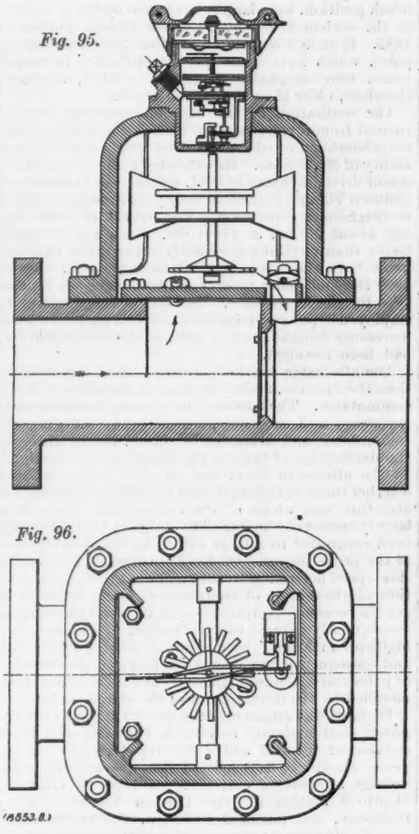


Fig. 94. Mercury Type Air Meter; Messrs. George Kent, Limited.



Figs. 95 and 96. Shunt Type Air Meter; Messrs. George Kent Limited.

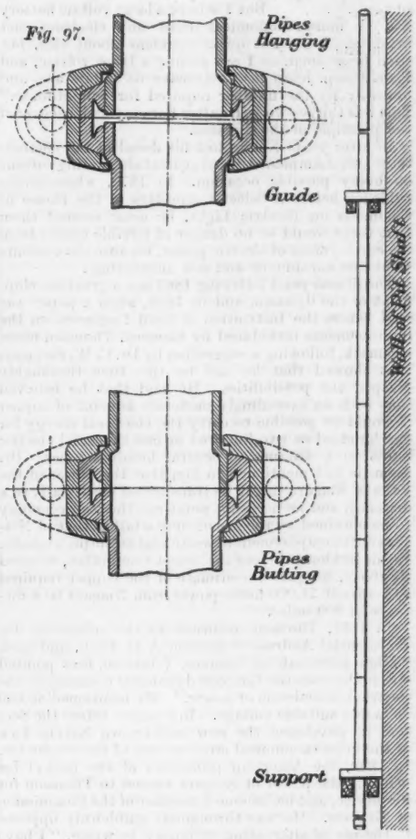


Fig. 97. Air Main in Shaft; The Victualic Co., Limited.

effect that of a uniflow type engine, in which the air passes through the cylinder from the bottom to the top. The inertia of the piston causes the inlet valve to open at the commencement of the down stroke. The compressor has forced lubrication. An automatic centrifugal clutch coupling is fitted, which enables the motor to start up entirely without load, the load being automatically transferred to the motor as the speed is accelerated; when the normal speed has been reached, the drive is positive. The motor drives through a pinion having a fabroil face with mild steel end plates.

The maintenance of the proper pressure in the mains in the case of air supply is a source of difficulty between the men working at the face and those at the compressor station. It is therefore of great importance that a check should be kept upon the pressure at which the air is delivered, its quantity, and the pressure at which it is actually used in the mine. In the colliery workings and in the surface plant several types of air meter, manufactured by Messrs. George Kent, Limited, of Luton, are in use. The output from the Walker air compressor is measured by a Kent mercury-type air meter (Fig. 94), the moving parts of which consist of the mercury in a U-tube, one limb of which contains a float, the movement of which actuates the pen-arm and counter. The Broom and Wade air compressor is fitted with a meter of the "boiler load indicator" type, a description of which has already appeared in Engineering (vol. cxv) of February 23, 1923, page 234.

The 2-in. air supply to the Diamond coal cutter has a 2-in. shunt-type meter, illustrated in Figs. 95 and 96, which is driven by a turbine mechanism of identical size, whatever may be the diameter of the main to which the meter is fitted. The only parts of the meter that vary are the body casting which contains the orifice, the orifice itself, and the change wheels, which are fitted in the counter train. The meter is designed to register down to one-tenth of the nominal maximum flow, and up to 40 per cent. above it, the pressure loss being about 1 lb. per square inch at the specified maximum flow. The meter registers on the counter the actual volume of compressed air passing at the temperature and pressure existing in the meter.

The air to the Climax and Siskol rock drills is measured by 1½-in. Kent "gate" type air-flow indicators, a type of indicator that consists essentially of a light hinged gate, working in a circular cavity and controlled by a spring. Ports are formed in the walls of the cavity, of such shape that the movement of the gate is proportional to the flow. The whole of the working parts are carried on one plate, so that they may be easily removed for inspection or cleaning. These indicators are designed for a pressure drop at full load of approximately ¾ lb. per square inch. In the case of meters of this size, it is necessary to allow a capacity of 1 to 2 cub. ft. by the provision of a sufficient length of pipe line or by a receiver in the air connection between the meter and the tool that causes pulsations in the air flow. A larger capacity of from 3 to 5 cub. ft. is required in the case of 2½ in. meters, the larger or smaller of these figures being dependent upon the rate of pulsation.

The pipes and joints, both for water and compressed air, have been supplied by the Victualic Company, Limited, of 28, Victoria-street, S.W. 1. We have already illustrated joints of this type in Engineering (vol. cxvii) of February 15, 1924, page 205, in connection with their ability to stand positive and negative pressures, that is to say, pressure or vacuum on the same joints. We now give (Fig. 97) two sections of pipe showing the adaptability of this jointing system to pipes as carried on the wall on the pit shaft, with some portions of the length butting and some hanging. Where the water and compressed-air pipes are carried horizontally underground, they are suspended from the roof girders or timbers by the convenient "Munzing" pipe hangers and brackets, with screw adjustments, which provide for adjustment of the height of the pipe, and calliper hooks that permit the pipes to be put into place or removed rapidly.

(To be continued.)

A HUNDRED YEARS OF ELECTRICAL ENGINEERING.*

Professor G. W. O. Howe, D.Sc.

This Section of the British Association, over which I have the honour to preside, is concerned with the whole field of engineering, civil, mechanical and electrical. As an electrical engineer, I felt that I should be expected to deal with some branch of electrical engineering—indeed, I should not feel competent to discuss any other branch—but, in view of the facts to which I have referred, I decided not to deal in detail with any single section of the subject, but to review the past development and present position of the subject as a whole.

If any one event can be regarded as the birth of electrical engineering, it is surely the discovery by Faraday in 1821 of the principle of the electro-motor; that is, that a conductor carrying a current in a magnetic field experiences a force tending to move it. It is noteworthy that ten years elapsed before Faraday discovered, in 1831, magneto-electric induction; that is, the principle of the dynamo. Four years later, Sturgeon added the commutator or "uniodirective discharger," as he called it, and in 1845 Cooke and Wheatstone used electromagnets, which Sturgeon had discovered in 1825, instead of permanent magnets. It was during the years 1865-1873 that the shunt and series self-excited dynamo, using a ring or drum armature and a commutator of many segments, finally evolved.

One of the earliest applications of the dynamo was for lighting arc lamps in lighthouses. In 1863 Thomson, writing to a friend on the relative merits of the Holmes direct-current and the Nollet alternating-current lighthouse machines, says, "Thus Nollet escapes the commutator, a great evil, and gets a flame which does not burn one of the points faster than the other. The reverse of each proposition applies to Holmes. The

* Abstract of Presidential Address to the Engineering Section of the British Association at Toronto, August 7, 1924.

commutator is a frightful thing . . . the thing to be done at the requisite speed is appalling. However, Holmes does it successfully. But I believe it cannot be done except theoretically without great waste of energy and consequent burning of contact surfaces. . . . But I believe a large voltaic battery will be more economical than any electromagnet machine. I am not quite confident about this, but shall be so soon, as I am getting a large voltaic, and I shall soon learn how expensive its habits are, and multiply by the number required for a lighthouse." This was thirty-two years after Faraday had discovered the principle of the dynamo.

In after years Kelvin lost his dread of the commutator and championed direct against alternating current on every possible occasion. In 1879, when giving evidence before a Select Committee of the House of Commons on Electric Light, he even assured them that there would be no danger of terrible effects from the employment of electric power, because the currents would be continuous and not alternating!

The fifteen years following 1863 saw a great development of the dynamo, and in 1878, when a paper was read before the Institution of Civil Engineers on the improvements introduced by Siemens, Thomson made a remark, following a suggestion by Dr. C. W. Siemens, that showed that he had by this time thoroughly grasped the possibilities. He said that he believed that with an exceedingly moderate amount of copper it would be possible to carry the electrical energy for one hundred or two hundred or one thousand electric lights to a distance of several hundred miles. Dr. Siemens had mentioned to him that the power of the Falls of Niagara might be transmitted electrically to a distance, and he need not point out the vast economy to be obtained by the use of such a fall as that of Niagara or the employment of waste coal at the pit's mouth. In his evidence before the Select Committee, referred to above, he gave an estimate of the copper required to transmit 21,000 horse-power from Niagara to a distance of 300 miles.

In 1881, Thomson returned to the subject in his Presidential Address to Section A at York, and said, "High potential, as Siemens, I believe, first pointed out, is the essential for good dynamical economy in the electric transmission of power." He mentioned 80,000 volts as a suitable voltage. In a paper before the Section he developed the now well-known Kelvin Law of the most economical cross-section of the conductor. In 1890, the American promoters of the project for utilising the power of Niagara turned to Thomson for his advice, and he became a member of the Commission of Experts. He was throughout stubbornly opposed to the use of alternating currents; he wrote, "I have no doubt in my own mind but that the high-pressure direct-current system is greatly to be preferred to alternating currents. The fascinating character of the mathematical problems and experimental illustrations presented by the alternating-current system and the facilities which it presents for the distribution of electric light through sparsely populated districts have, I think, tended to lead astray even engineers, who ought to be insensible to everything except estimates of economy and utility." He was in a hopeless minority, however, in this view, and the Falls of Niagara were harnessed to two-phase alternators with an output of 3,500 kw. each. Kelvin was present at the meeting of the British Association held in this city in 1897, and shocked many people by saying that he looked forward to the time when the whole water of Lake Erie would find its way to the lower level of Lake Ontario through machinery; "I do not hope," he said, "that our children's children will ever see the Niagara Cataract." Although he was apparently very much impressed with the success of the Niagara system, he was not converted from his allegiance to direct currents, for at his last appearance at the Institution of Electrical Engineers, in 1907, he said, "I have never swerved from the opinion that the right system for long-distance transmission of power by electricity is the direct-current system."

One of the earliest complete house-lighting installations was put in by Kelvin in 1881. A Clerk gas-engine was used to drive a Siemens dynamo, a battery of Faure cells was fitted up, and every gas-light in his house and laboratory at Glasgow University was replaced by 16 candle-power Swan lamps for 85 volts. He had to design his own switches and fuses, &c., for such things were almost unknown.

Returning to the development of the direct-current dynamo, it may be noted that the drum armature, now almost exclusively employed, was invented in 1872 by von Hefner Alteneck, and gradually displaced the ring armature of Pacinotti and Gramme. Although Pacinotti's original ring armature was slotted, smooth armatures were preferred for many years, until the mechanical superiority of the slotted armature caused the disappearance of the smooth core with its wooden driving pegs, which were employed to transmit the turning moment from the core to the conductors. The commutator and brushes were a great source of trouble, but, by the gradual elimination of unsuitable material and by better design and methods of manufacture, the commutator has been made a most reliable piece of apparatus. The difficulties of commutation, and especially the need of continual adjustment of the brush position, were largely overcome by the invention of the carbon brush by Professor George Forbes in 1885. It should be pointed out that the commutating poles, which have come into use so much in recent years, were originally suggested in 1884, and are, therefore, older than the carbon brush.

The realisation of the idea of supplying electric current from a power station for lighting houses in the neighbourhood owed much to the energy and business ability of Mr. Edison. He exhibited his first "Jumbo" steam-driven dynamo in 1881, and installed two sets at Holborn Viaduct in the following year to supply current to neighbouring premises. The output of these sets was about 90 kw. at 110 volts, which was so much larger than anything previously constructed that the name "Jumbo" was applied to these sets. About 1890 the multipolar type began to replace the bipolar type for the larger sizes. The size of the single units employed in power stations gradually increased with the increasing demand, and by 1895 dynamos of 1,500 kw. had been installed.

The alternator has had a more varied development than the dynamo, mainly because of the absence of the commutator. The necessity of keeping the brush gear stationary and accessible, and therefore allowing the commutator and armature to rotate, led to an early standardisation of type in the direct-current machine. In the alternator there was no such limitation, and whether the field system should be inside or outside the armature and which of the two should rotate were largely matters of choice. The design of alternators has been controlled to a large extent by the development of the prime mover. On the Continent of Europe the slow-speed horizontal steam-engine led to the construction of alternators of enormous diameter in order to get the necessary peripheral speed, the axial length being consequently reduced to a few inches. In England the high-speed marine-type engine was generally preferred, and consequently the alternators had a smaller number of poles and a smaller diameter. All this has now been modified by the development of the steam turbine.

Ferranti was apparently the first to suggest that the power station should be outside the city, at a point convenient for fuel and water supply, and that the power should be transmitted into the city by high-voltage alternating currents. In 1890 he built the Deptford station for the London Electric Supply Company, and installed 1,000-kw. 10,000-volt alternators. This was the pioneer high-voltage underground cable transmission, and much was learnt concerning the peculiarities of alternating currents when transmitted over cables of considerable capacity. The following year, 1891, saw the first long-distance transmission by means of overhead conductors in connection with the electrical exhibition at Frankfort-on-Main; three-phase power was transmitted, at 8,500 volts, from a water-power station at Lauffen to Frankfort, a distance of 110 miles.

This development of the use of high-voltage alternating currents followed the development of the transformer. Gaulard and Gibbs patented a system of distribution involving transformers in 1882, and, although their patent was upset in 1888 on the ground of its impracticability, the present method of using transformers for the distribution of electrical power was introduced in 1885, and shown at the Inventions Exhibition in London in that year. Although from 1890 onwards there has been a steady increase in the size of alternators and transformers and in the voltage employed for long-distance transmission, the last few years have seen a really amazing increase in the size of the units employed. In 1913 the largest two-pole turbo-alternators had an output, at 3,000 r.p.m., of about 7,500 kw.; such machines are now made up to 30,000 kw., and four-pole alternators are running at 1,500 r.p.m., with an output of 60,000 kw. This increase in size and in peripheral speed has been made possible by improvements, both in the material and in the design. With a bursting speed 25 per cent. above the running speed, the peripheral speed can now be raised to 150 m. per second. Improved methods of cooling and a better understanding of the various causes of loss in the armature have enabled the materials to be used at higher current and flux densities.

This great increase in the size of units is not confined to the steam turbo-generator, as can be seen from the water-turbine sets recently added to the Niagara installation. Whereas the original Niagara turbines were of about 5,000 h.p., the new ones have an output of 70,000 h.p. at the low speed of 107 r.p.m.

The importance of cheap electric power has led to this great increase in the size of the units in the generating stations. Any slight difference of efficiency between a 10,000-kw. and a 60,000-kw. alternator is of little importance, and would certainly not counterbalance the decreased factor of safety due to concentrating the whole power supply in three or four large units, instead of distributing it between a dozen or more units. The reason for the adoption of the smaller number of large units lies almost entirely in the decreased capital cost per kilowatt of plant.

In connection with the conversion of alternating to direct current, mention should be made of the mercury arc rectifier. Great improvements have been made in recent years, especially in Switzerland, and a number of high-power arcs have been installed in sub-stations. Although they have the advantage of doing away with running machinery, the modern rotary-converter is such a reliable piece of apparatus that it is very questionable whether it will be replaced to any considerable extent by the mercury-arc rectifier.

Until recently, the only means of producing a large amount of high-voltage direct-current power was by connecting a large number of carefully insulated dynamos in series, as in the well-known Thury system of power transmission. Within the last two or three years another method has been developed, viz., the so-called transverter, which consists of an arrangement of transformers and a system of rotating brushes whereby a three-phase alternating-current supply is converted into an almost steady continuous current. The first apparatus of this type to be exhibited is installed at the British Empire Exhibition at Wembley, and is designed to deliver continuous current at 100,000 volts. It can also be used for the reverse process. It would thus enable a three-phase generating station and a three-phase sub-station to be connected by a direct-current transmission line, thus avoiding not only the maximum voltage of 1·4 times the effective voltage, which was one of Lord Kelvin's objections to the alternating-current system, but also all trouble due to the capacity and inductance of the line. Whether the disadvantages of the transverter, when it is fully developed—it is yet in its infancy—will more than outweigh these advantages remains to be seen, but, apart from the transmission of power, the device may have many applications.

Electric traction represents one of the most important branches of electrical engineering. It shares with the petrol motor the distinction of having absolutely revolutionised the methods of transport within a single generation. In its origins it is nearly a century old, for attempts were made in the 'thirties to apply Faraday's newly discovered principle to the propulsion of vehicles, but, with very primitive motors and primary batteries, these attempts were doomed to failure. The development of the dynamo and motor in the 'seventies opened the way to further experiments, and at the Berlin Exhibition in 1879 a line one-third of a mile long was shown in operation, a locomotive drawing three cars. The first regular line was opened to traffic near Berlin in 1881; it worked at 100 volts and the current was collected from an insulated rail. Toronto was the scene of one of the earliest experiments in America; C. J. van Depoele, after some experiments at Chicago in 1882 and 1883, ran an electric locomotive in 1884 between the street-car system and the Exhibition in Toronto.

Although 500-volt D.C. supply has been standardised for street tramways, the relative merits of D.C. and A.C. for electric railways has been a burning topic for over twenty years, and is now perhaps more burning than ever. It is somewhat akin to the battle of the gauges in the early days of steam railways, for it involves, in many cases, the problem of through running, if not now, in the not very distant future. Although the three-phase system was successfully installed in Northern Italy, it has grave disadvantages, and the battle now is confined between direct current at an increased voltage of, say, 1,500 to 2,000 volts, and single-phase alternating current. In the latter case, there is, moreover, a further question as to the best frequency to adopt, this being usually either 25 or $16\frac{2}{3}$. The development of the A.C. commutator motor to the stage where it was applicable to traction took place during the first few years of this century, and, although it is inferior to the D.C. motor, it introduces so many simplifications and economies in the transmission of the power from the generating station to the train that experts are very divided as to the relative merits of the two systems for main-line electrification.

I turn now to what may be called both the earliest and the latest application of electricity; that is, its use for transmitting intelligence. One of the greatest factors in the development of our modern life has undoubtedly been the network of wires and cables which has spread over the whole earth, making an almost instantaneous transmission of intelligence and interchange of opinions. In the early days of electrical science, the discovery of a new property of electricity was followed by attempts to utilise it for this purpose. As early as 1746 there are records of the use of frictional electricity for the purpose, and distances up to four miles were tried. In 1774, Lesage, of Geneva, proposed 26 wires in earthenware pipes with

pairs of pith-balls at the end of each wire, which flew apart when the conductor of a frictional machine was brought near the other end of the wire. A current of electricity was unknown until Galvani's discovery in 1789, and Volta's pile was first constructed in 1792. Carlisle, in 1800, found that water was decomposed by passing the current from a Volta pile through it, and this was the basis of the telegraph proposed by Sömmering in 1809, in which 26 wires ended in 26 metallic points arranged in a row along the bottom of a kind of aquarium. By means of a lettered keyboard at the sending end the current could be applied to any wire, and a stream of bubbles caused to rise from the appropriate point, each point being duly labelled with its appropriate letter. The magnetic effect of the electric current was discovered in 1819, and immediately replaced the previous methods in efforts to develop an electric telegraph; except for the attempts to make a high-speed chemical telegraph, all subsequent telegraph systems have employed the magnetic effect of the current. A great many of the fundamental inventions of telegraphy were made in the 'thirties; the list includes the needle instrument of Cooke and Wheatstone, the sounder of Henry, the dot-and-dash inker of Morse, and the use of the earth as a return by Steinheil. Although the needle instrument is now obsolete, the sounder and Morse inker are still commonly employed. Many have been the devices for increasing the amount of traffic which can be worked over a single line, either by the simultaneous use of the line by a number of operators, as in the quadruplex and multiplex systems, or by punching the messages on paper tapes, which can then be fed into an automatic transmitter working at a speed ten to twenty times that attainable by a manual operator. In the most up-to-date systems, the perforation of the tape is done by the operators working an ordinary typewriter keyboard, and the received message is printed in ordinary type, a single wire carrying eight messages simultaneously, four in either direction, at a speed of 40 words per minute.

The first cable was laid across the Atlantic in 1858, and, although in the light of our present knowledge we know that it could not have had a very long life, its failure after a few weeks of preliminary communication was primarily due to misuse owing to the ignorance of those in charge. Although much costly experience had been gained in the laying of cables in various parts of the world since this first attempt to span the Atlantic, the success of the second Atlantic cable, in 1866, was largely due to the scientific ability of Kelvin and to his enthusiastic and untiring application to the project at every stage of the manufacture and laying of the cable. In addition to this, he not only designed the receiving instruments, but superintended their manufacture in Glasgow and their installation and operation. The success of the Atlantic cable was to a large extent a personal triumph for Lord Kelvin. Although numerous improvements have been made in the details of cable manufacture and in the transmitting and receiving apparatus, no outstanding change has been made in recent years in the methods of submarine telegraphy.

Turning to another branch of electrical communication, it is no exaggeration to say that modern business life has been revolutionised by the telephone, which will shortly celebrate its jubilee, for it was in 1876 that Graham Bell invented the magnetic telephone receiver, although others, notably Reis, had been working at the problem since 1861. Bell showed his telephone in operation at the Philadelphia Centennial Exhibition in 1876, and Kelvin, who was one of the judges, brought one back with him and demonstrated it to Section A of the British Association, at its meeting in Glasgow in the autumn of 1876.

A successful telephone system requires much more than efficient transmitters and receivers, and the great development which has taken place has been largely a matter of improvement in the design of the many elements that go to make up a telephone exchange. The modern manual central-battery exchange, in which one has only to lift his receiver to call the operator and be connected in a few seconds to any one of 10,000 other subscribers, is a marvel of ingenuity and construction. But this is now gradually being replaced by the greater marvel of the automatic system, in which the operator is eliminated and the subscriber automatically makes his own connection to the desired subscriber. Attention should be drawn to two outstanding inventions in the actual transmission of telephony over long distances, viz., loading and repeaters. It was Oliver Heaviside who, in 1885, proposed to improve the range by increasing the inductance of the line. Although this revolutionary suggestion fell on deaf ears for fifteen years, it ultimately proved to be one of the great inventions of telephony; it is of special importance in underground and submarine telephone cables, the electrostatic capacity of which otherwise seriously limits the range. The other outstanding novelty is the introduction of repeaters at intermediate points in long telephone lines. These repeaters are specialised types of low-frequency amplifiers; they were made commercially possible by the invention and perfection of the three-electrode thermionic valve. The attenuated speech currents arriving at the end of a section of line are amplified, and thus given a new lease of life before being passed on to the new section. By using a large number of such repeating stations, telephonic communication has been established between New York and San Francisco. But in addition to making such long-distance communication possible, the use of repeaters enables medium distances to be bridged by relatively cheap lines of high attenuation.

Turning now to radio telegraphy and telephony, one cannot but marvel at the rapidity of its development, and the inroad that it has made during the last two or three years on the domestic life of the whole civilised world. The theory of Clerk Maxwell in 1864, and the laboratory experiments of Hertz in 1888, found their first practical application in Marconi's Italian experiments in 1895 and his demonstrations in England during the following year. Much of the rapid progress was due to his perseverance, vision, and courage in perfecting apparatus for short-distance work, and simultaneously experimenting over long distances, and thus, in the year 1901, settling by actual demonstration across the Atlantic the vexed question as to whether the waves would pass around the earth over distances of several thousand kilometres or go off into space.

INDUSTRIAL NOTES.

A CLAIM submitted by the Boilermakers' Society to the London, Midland and Scottish Railway for the restoration of extra payments to the charge hands and boiler examiners in some of the company's running sheds was decided upon on Monday by the Industrial Court. The Boilermakers' Society claimed that previous to the Award No. 728, an allowance of 4*s.* per week was paid to the charge hand boilermaker at Newton Heath, and allowances of 2*s.* per week to the boiler examiners in some sheds, but after the award the allowances were reduced, in the case of the charge hand, and withdrawn in that of the examiners. The company replied that in the case of the charge hand the allowance was adjusted on the analogy of Award No. 826 dealing with charge hand fitters in running sheds, and that the work of the examiners had been reorganised prior to the issue of Award No. 728. The Industrial Court decided that a case had not been made out for interfering with the present rate of the leading hand, and, as regards the boiler examiners, it found that, as the work for which an allowance was paid previously to them was not now being performed by them, the claim had not been established.

A special Tribunal, under the presidency of Sir William Mackenzie, formed to consider an application from tramway workers for higher wages, concluded its sittings in London last Friday. The decision arrived at, on the employers declaring their inability to pay more, and in view of the undesirability of raising the fares, was to recommend to the National Industrial Council the suspension of the notice for improved wages conditions for a period of three months, during which period the present rates of pay are to continue, thus giving the Tribunal time to arrive at a settlement.

With reference to our note on page 141 *ante*, a statement was issued last Friday by Mr. W. J. Webb, secretary of the trade union side of No. 10 Area Council, saying that the trade union side of No. 10 Council, Greater London Area, for the electricity supply industry (comprising the Electrical Trades Union, the Amalgamated Engineering Union, the Workers' Union, the National Union of Enginemen, Firemen, and Electrical Workers, and the National Union of General and Municipal Workers), had been informed of the decision come to at the meeting of the executive councils of the unions which are parties to the National Joint Industrial Council for the electricity supply industry in respect of the national claim for a 10*s.* per week advance to workers employed in electricity undertakings; they had notified the employers' side of No. 10 Council that they were supporting the decision of the executive councils, and that unless a satisfactory settlement in respect of this claim were arrived at by August 15, all the workpeople employed in electricity undertakings in the Greater London area, including tramways and railways, would be instructed to cease work.

The conference of the unions connected with the engineering trades took place on July 31, as announced in our issue of July 25. The following statement, issued at the close by Mr. J. T. Brownlie, president, and Mr. Frank Smith, secretary, explains the present position:—"Representatives of the 41 unions concerned in the application for an advance in wages of 20*s.* per week, as made to the Engineering and Allied Employers' Federation, met in conference at the St. Pancras Hotel, to receive the reports of the respective executives. On consideration of these reports, it was decided that the unions agree by resolution that they will act jointly and unitedly in pressing the claim to a successful issue. It was also agreed that a committee of one representative from each union, with the chairman (Mr. Brownlie) and the secretary (Mr. Frank Smith), be appointed to examine the statements made by the employers and report to a further conference thereon when further action shall be determined. The first meeting of the committee is to be held in London on the 12th inst."

The dispute in the building trades remains unsettled. A conference at the Ministry of Labour was held on Wednesday, under the chairmanship of Sir David Shackleton. There were present representatives of the National Allied Building Trade Employers, including representatives of the Liverpool Employers' Association, representatives of the National Federation of Building Trades Operatives and representatives of the Liverpool Operatives. The conference was adjourned until yesterday. It was agreed that, in the meantime, a meeting should take place between the Liverpool employers and operatives, both sides to report to their respective bodies before the adjourned conference.

The Ministry of Labour states that during the first half of June there was a decline in employment, the Whitsuntide holidays having been extended in many cases. In the second half of the month there was a recovery, and at the end of June the number of workpeople unemployed was about the same as at the end of May.

There was, on the whole, a further rise in wages in June. In the industries for which statistics are available, the changes in the rates of wages reported resulted in an aggregate increase of nearly 103,000*l.* in the weekly full-time wages of 595,000 workpeople, and in an aggregate reduction of 11,000*l.* in those of over 150,000. There was an increase of 1*s.* per day, or 6*d.* per half-day, in the wages of dock labourers; seamen, firemen, &c., in the merchant shipping service obtained increases of 10*s.* or 15*s.* on monthly rates and 2*s.* 6*d.* to 3*s.* 3*d.* on weekly rates; and the majority of shipyard workers in the principal shipbuilding centres received advances amounting to 3*s.* per week in the case of piece-workers and the higher-paid time-workers, with smaller amounts in the case of lower-paid time-workers. Other workers whose wages were increased included iron puddlers and millmen in the Midlands and the West of Scotland, and heavy chemical workers and brick makers in various districts. The principal groups of workpeople whose rates of wages were reduced included coal miners in Northumberland, iron ore miners in Cumberland, steel sheet millmen and chainmakers.

During the first six months of 1924 the changes reported to the Labour Department have resulted in net increases equivalent to about 580,000*l.* in the weekly full-time wages of over 2,900,000 workpeople and in net reductions of 23,000*l.* in the weekly wages of 317,000. On July 1, the average retail prices of commodities was approximately 70 per cent. above that of July, 1914, as compared with 69 per cent. both a month ago and a year ago.

The number of trade disputes involving stoppages of work reported to the Labour Department as beginning in June was 57. In addition, 35 disputes which began earlier were still in progress. The total number of workpeople involved in all disputes in June was approximately 50,000 as compared with 36,000 in the previous month. The estimated aggregate duration of all disputes during June was about 356,000 working days as compared with 398,000 during May.

Speaking at the thirty-third annual general meeting of Messrs. Furness, Withy and Co., Limited, the chairman, Sir Frederick W. Lewis, Bart., referred to foreign competition in the matter of coal, steel, &c., and instanced various recent contracts which had been lost to this country. The chief factor, he said, was the cost of labour, and in reckoning the cost of labour, regard had to be had to the number of hours worked and the amount of work produced; this, he added, was the crux of the whole situation. At the leading Continental ports, dockers' wages were, on the average, about 40 per cent. less than those prevailing in United Kingdom ports, and the total cost of delivering a cargo at the Continental ports averaged about 38 per cent. less than at the principal British ports. The average of seamen's wages on the Continent, *i.e.*, averaged over the whole of our Continental competitors, was about 30 per cent. less than those paid to British seamen. On top of these disparities this country had to bear greater internal costs in rates and taxes. Sir Frederick expressed his satisfaction at the decision taken by Government to appoint a committee to enquire into these matters; he hoped it would be possible to evolve some satisfactory scheme for reducing the cost of living and the cost of labour, the effect of which, he felt sure, would be a speedy revival in our foreign trade.

THE CABLE-LAYING AND REPAIRING STEAMER "EDOUARD SUENSON."

CONSTRUCTED AT THE ROYAL DANISH DOCKYARD, COPENHAGEN, DENMARK.

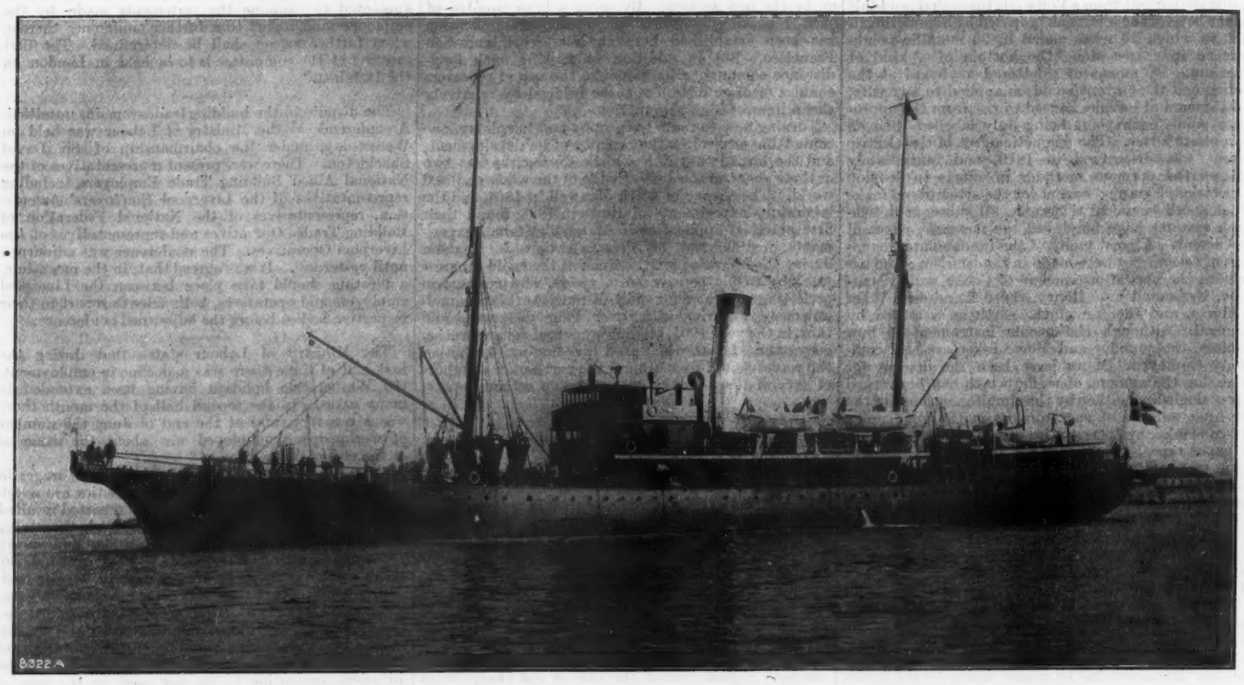


Fig. 1.

THE CABLE-LAYING AND REPAIRING STEAMER "EDOUARD SUENSON."

For cable laying a steamer must be constructed so that she can carry heavy loads of cable and the gear for its handling, and in addition must have large bunker accommodation and water tanks as she must remain at sea for long periods. These conditions make the design different from that of other vessels, but the additional loads may be so distributed as to remove the necessity for excessive strength in any section. In the illustration above is shown the cable ship Edouard Suenson, a vessel in which the load distribution throughout the length has been very well thought out. She was built for the Great Northern Telegraph Company of Denmark at the Royal Danish Dockyard (Orlogværftet), Copenhagen, under special survey by Lloyd's Register, and classified 100 A1, for the type of vessel, with awning deck and freeboard. Provision had to be made for the carrying of 700 tons of cable, 100 tons of cable gear and operating engines, 280 tons of liquid fuel or coal and fresh water for at least 30 days, as the vessel is intended for service in the Baltic, the North Sea and the North Atlantic Ocean.

The Edouard Suenson is a steel vessel of 1,552 tons gross, with an awning deck, and propelled by an engine of 1,100 h.p. through a single screw. Her stern is of the cruiser type. The rudder post, the stern post and the lower part of the stem are somewhat stronger than is customary in this class of ship and are all made of cast steel. To the flat keel of the vessel there is riveted a false one made up of steel sections. A considerable amount of flare is noticeable at the bow (see Fig. 1), which is necessary in order to obtain a good working platform at the fore part of the awning deck. The stern, which carries two bow sheaves, the forepart of the vessel generally, and the plating above and below the waterline, where there is a cable tank, which carries approximately 300 tons of cable, are all made of substantial dimensions, not only to satisfy the load requirements but to resist wear from the cables and possible injury from ice. Bilge keels are fitted amidship, and there is a system of chafing bars provided in the forepart from the keel to the water line. The hull is subdivided by transverse bulkheads into seven watertight compartments. A double bottom of cellular construction extends the whole length of the ship except under the boilers. Fore and aft peak tanks are provided for use in trimming. The after one has a capacity of 78 tons while the fore one has accommodation for 19·4 tons and beside it is situated a deep bottom tank which holds 79 tons.

The hull and machinery of the vessel, excepting the cable gear and the auxiliaries, were constructed by the Royal Danish Dockyard. In Fig. 1 an illustration is given of the ship at sea from which her lines may be appreciated. The sectional elevation in Fig. 2 on Plate XVIII, and the deck and hold plans in Figs. 3 to 5, afford information on the lay-out of the machinery, cable tanks and bunkers, as well as the accommodation for the officers and crew. The principal dimensions are :—

	Metres.	Ft.
Length between perpendiculars	71·5	(234·6)
Breadth moulded	10·7	(35·1)
Depth moulded up to awning deck	7·36	(24·14)
Depth moulded up to main deck	5·11	(16·76)
Draught loaded	4·83	(15·85)
Displacement at loaded draught in sea-water of 1·015 density	2,520 tons.	

The speeds specified to the constructors were 10 knots as the normal and 11 knots as the maximum, which the vessel was expected to maintain for several days. On the trials, with the ship nearly fully loaded, a maximum speed of 11·5 knots was obtained with an indicated horse power of 1170. During the trials the ship fulfilled the requirements of the owners, and her first voyage was made in heavy weather in the North Sea when her seagoing qualities were well demonstrated.

The captain's accommodation, consisting of a saloon and sleeping cabin, is beside the radio room and the chart room on the midship deck. A large test room is provided immediately below in the deckhouse, beside which there is accommodation for the chief electrician. The position of the test room is well suited to effective oversight of the cable work which is done on the fore deck. In the after deckhouse there are three cabins for use of the six quartermasters and separate mess rooms for them, for the stokers and for seamen and cable hands as well as a carpenter's workshop. On the main deck amidship are situated the dining saloon and the officers' mess with adjacent pantry, and cabins for the chief engineer, officers, engineers and assistant electricians. There are also four cabins for passengers. All these rooms are effectively ventilated and well furnished. Additional accommodation for the crew is provided forward and aft on this deck. There are four lifeboats of 22 ft. length, a 24 ft. 8 in. motor boat and a dinghy provided, for which davits are available on the boat deck. The motor boat is built of oak and has an 8-h.p. Hera engine. Mills's release gear is used for all these boats.

Three cable tanks are provided on the vessel, the fore one of which is of 7·2 metres (23·6 ft.) diameter, the main one is larger, being of 8·3 metres (27·2 ft.) diameter, while the aft one is of 7·5 metres (24·6 ft.) diameter. In all, these three tanks have a capacity to the tops of the cones of 16,000 cub. ft., and can store 700 tons of cable. The fore and the main tanks rest upon the top of the inner bottom plating, and are carried up to the level of the main deck, but the after tank is put on the top of the shaft tunnel and carried up to the awning deck. The cable hatches are provided with girders carrying bell-mouths. Each tank is provided with a crinoline and has a centre cone in which fresh water is stored. Immediately forward of the after tank is the engine room in which the main engines are accommodated. The cable engines are erected forward on the main deck and their construction will be referred to later in this article.

Drawings of the main engine are reproduced in Figs. 6, 7 and 8 on Plate XVIII. The engine is a simple triple-expansion one, with the cranks set at 120 deg. The cylinder dimensions are : H.P., 430 mm. (16·9 in.), I.P., 720 mm. (28·4 in.) and L.P., 1,160 mm. (45·6 in.), and the stroke is 800 mm. (36·6 in.). When the engine is running at 120 r.p.m., with the steam supplied from the boilers at a pressure of 13 kg. per square centimetre (185 lb. per square inch), and with the superheat obtained from the Schmidt superheater, 1,100 i.h.p. is generated. The construction of the engine is clearly shown in the illustrations. The cylinders are erected on cast columns, which also carry the crosshead guides, at the back and on tubular steel pillars at the front. The crosshead guide is of the closed type. Stephenson gear is fitted with the usual weigh shaft and weigh bar for the adjustment of the individual link systems to suit any desired condition of distribution of power between the cylinders when running ahead and yet giving the standard power relationship when running reversed. For reversal a simple worm and worm wheel, operated by hand, serve to give the requisite turning of the weigh shaft. Piston valves are fitted to the H.P. and I.P. cylinders, but a balanced flat valve is used for the L.P. and is provided with a balance piston above to relieve the operating link motion of the weight of the valve and its rod. In Fig. 9 the setting of the cranks and the time of opening to steam and exhaust of the three valves when running under normal conditions is clearly indicated. From the crosshead of the H.P. cylinder motion is taken by levers to operate the air pump and two bilge pumps. These with the main condenser are mounted on the engine frame. The thrust block is of the Michell

OIL-FUEL INSTALLATION ON THE CABLE-LAYING AND REPAIRING STEAMER "EDOUARD SUENSON."

CONSTRUCTED BY KORTING BROTHERS, ENGINEERS, HANOVER.

Fig. 10.

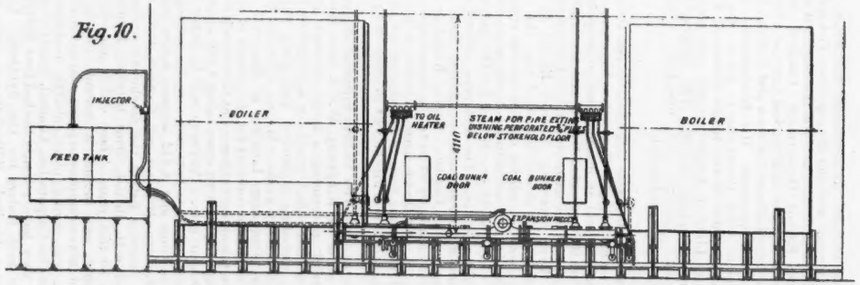


Fig. 11.

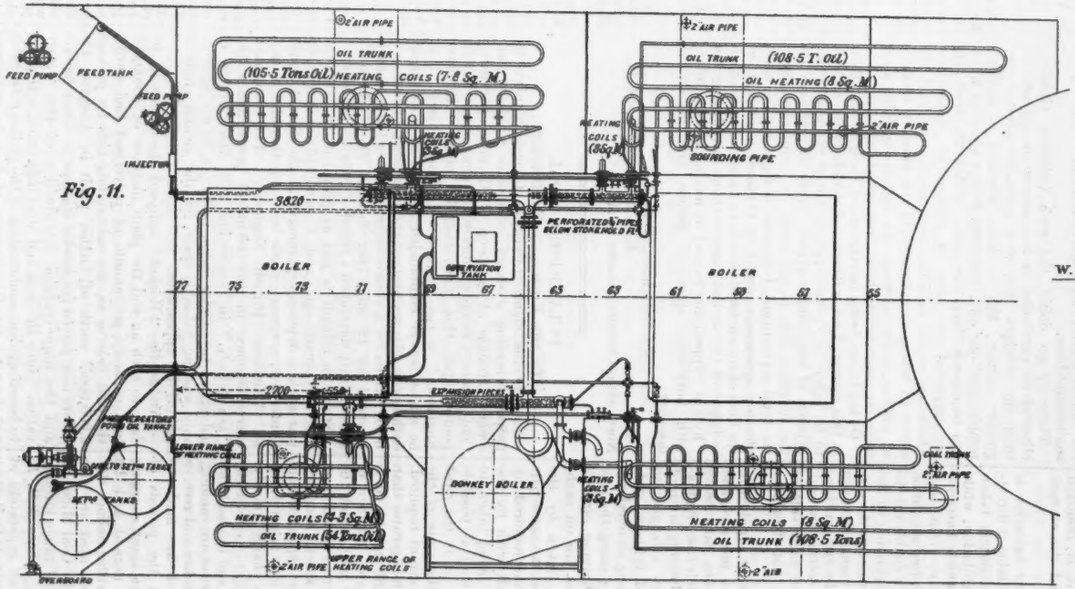


Fig. 12. AFT OIL BUNKER

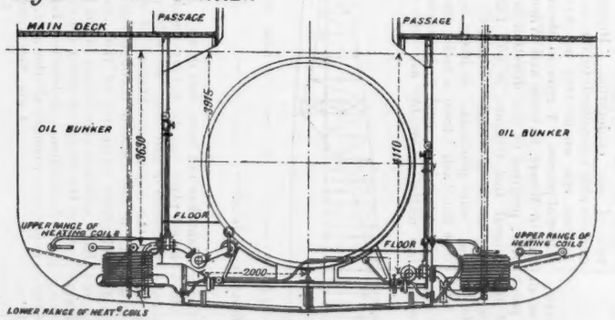
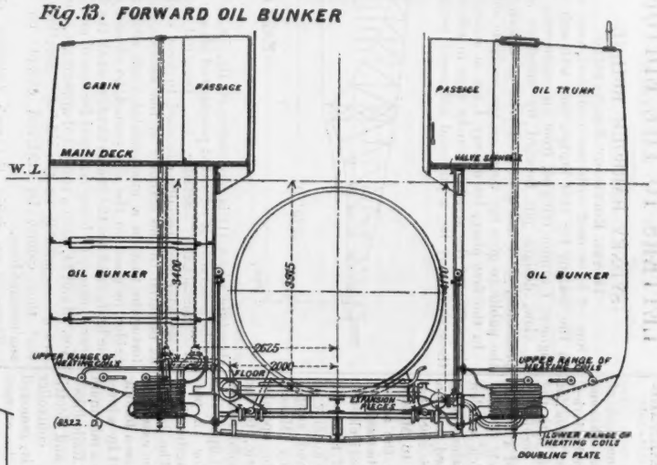


Fig. 13. FORWARD OIL BUNKER



pattern, and was supplied by Messrs. Vickers Limited. A four-bladed propeller made of bronze by Messrs. J. Stone and Co. is provided and has a diameter 10 ft. 8¾ in., a pitch of 11 ft. and a developed area of 40 sq. ft.

Steam for the engines is generated in two single-ended cylindrical boilers provided with Howdens forced draught system and superheaters constructed on the Schmidt system. The working pressure of the boilers is 13 kg. per square centimetre (185 lb. per square inch). A total heating surface of 310 sq. m. (3,350 sq. ft.), excluding the superheaters, is available. A donkey boiler supplied by Messrs. Cochran and Co. (Annan), Limited, of Annan, is placed beside the starboard side bunkers. This has a heating surface of 32·5 sq. m. (350 sq. ft.). All the boilers are fitted for oil burning and the bunkers are arranged to carry either oil or coal. The Korting system is used and the equipment consists of two steam-driven oil-fuel pumps, two oil-fuel heaters with filters, air vessels and starting heater. The whole of this equipment is arranged at the port side of the boiler-room. Although the bunkers are high, two settling tanks, with air and overflow pipes to an expansion trunk, are provided on the starboard side in the engine-room, and the oil is taken from the bunkers to these tanks by means of an electric-driven oil pump. The oil may, if necessary, receive a certain amount of heating in the bunkers by means of a steam pipe arrangement installed for the purpose, see Figs. 10 to 13. A further heating of the oil, to a temperature of 130 deg. F., takes place in the settling tanks in order to separate any water that may be present. The drain pipe from every oil-heating system is led to divisions in an observation tank to ensure that any leakage of oil into the heater system may be detected. The oil consumption is about 0·52 kg., or 1·15 lb. per hour per indicated horse-power, which includes the auxiliaries.

(To be continued.)

REPORTS ON ELECTRODE REACTIONS AND ON ATMOSPHERIC CORROSION.—The Faraday Society, of 10, Essex-street, W.C.2, has published full reports on two general discussions held by the Society last winter. The first report, on "Electrode Reaction and Equilibria," is a pamphlet of 170 pages the price of which is 10*s.* 6*d.* net, bound. We noticed this discussion on page 752 of our issue of December 14 last, and will content ourselves, on this occasion, with pointing out that Professor A. Smits, of Amsterdam, Mr. R. T. Lattey, of Oxford, and Dr. H. J. Sand have sent in further contributions to the discussion. The second report, a pamphlet of 93 pages [price 7*s.* 6*d.* net] is a reprint from the Transactions of the Society, of Mr. W. H. J. Vernon's "First (Experimental) Report to the Atmospheric Corrosion Research Committee of the British Non-Ferrous Meta's Research Association," and the discussion. We dealt with this discussion on page 778 of our issue for December 21 last. The further contributions to the discussion, now published, are by Dr. B. S. Evans and by Mr. H. C. Lancaster, while Mr. Vernon's reply has also been added.

THE "RAILODOK" ELECTRIC PASSENGER CAR.

Although for some years a popular method of moving materials in engineering shops, railway stations, &c., the electric truck, operating from storage batteries, appears to have been employed for the first time for extensive passenger transport in connection with the British Empire Exhibition. A constant service is maintained around the grounds by means of a fleet of cars numbering some two hundred. Each is constructed with a standard iron frame on which wooden boards are mounted to form a flooring, the whole being carried on two axles. At one end of the bed frame a vertical iron-supported panel carries the electrical control gear, the arrangement being due to Messrs. G. D. Peters and Co., Limited. Between the axles, underneath the flooring, 21 D.P. Kathanode batteries of the T.R.15 type, specially designed for use with electric vehicles by the D.P. Battery Company, of Bakewell, are mounted on the car. These have a capacity of 168 ampere-hours at the five-hour rate and supply current to a 3-h.p. motor, supplied by Messrs. Drake and Gorham, Limited. The motor operates through a gear, having a four-to-one ratio, to the wheels, which are of cast-iron and have solid rubber tyres. The frame of the car has mounted upon it a body having seating accommodation for 12 passengers, and is equipped with a canopy affording head cover to both passengers and driver. The latter's seat is affixed to a pillar carried on a floor extension projecting in front of the control panel, while a folding step runs the length of the vehicle, operated by a lever on the panel. The object of this is to secure a minimum travelling breadth. The driver's seat on all "Railodoks" is hinged and sprung, and so mechanically and electrically interlocked with the brake and controller that immediately the driver's weight is removed the brake is automatically applied and the current cut off.

The charging equipment for the car batteries is interesting. The electricity supply available is direct-current, three-wire, 440 volts between outers taken from the local power station in the Exhibition, while the voltage required for each of the vehicle batteries is approximately 55. It is necessary that any number of batteries from one to one hundred should be able to be charged at the same time. To enable this to be done, three copper conductors corresponding to the two outers and neutral of the supply are carried overhead down the centre of the charging garage. Between the outer and neutral on each side of the system three additional copper conductors of smaller section are laid, and a five-wire balancer introduced on each side of the neutral to take care of the out-of-balance current.

For the purpose of regulating the current supplied to individual vehicles, charging panels are provided and connected to the appropriate conductors, each being fitted with an ammeter, iron-clad switch fuse, regulating switch and resistance, and an indicating lamp of distinctive colour. These colours are arranged so that each corresponds to one group of vehicles, and, as all the charging panels are placed along an overhead gallery, the attendant can, by glancing along the row of panels, ascertain which of his charging circuits are operating and how many vehicles are on each. Any difference in the total current taken by the Kathanode batteries connected between the same pair of leads as compared with the amount required by those between any other pair is dealt with by the balancers previously mentioned, care being taken to keep this out-of-balance current as small as possible by placing the vehicles, as they come in, in the most suitable position, having regard to the state of the particular battery and the charging current required. As the balancers have a capacity which is greater than the normal charging current of a single battery, it is possible to charge simultaneously any number of vehicles, from one to the full number with which the plant is capable of dealing. The current is led from the charging panels to the vehicles by special insulated flexible leads fitted with charging plugs suspended from the garage roof immediately over positions taken up by the cars, so that they can be put on charge quickly. During the period when the Exhibition is closed the trucks are put on charge in two relays and the batteries fully charged. By day, while the services are running, the trucks return to the garage in batches and receive "boost charges" at intervals, which are made to correspond as far as possible with the periods of minimum traffic demand. During the boost charging the rate is several times higher than normal, and the lead battery used is capable of withstanding this treatment. The Kathanode batteries used are also fitted on the electric locomotive in the Coal Mine, on a Giant electric truck, and on a normal-gauge locomotive in the Palace of Engineering. These T.R. 15 batteries under discussion are on view separately at the Exhibition on the stand of Messrs. D.P. Battery Co., Limited, in the Palace of Engineering.

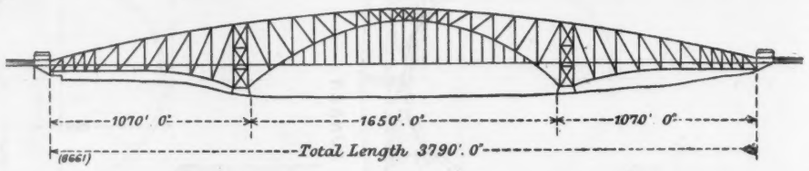
LETTERS TO THE EDITOR.

SYDNEY HARBOUR BRIDGE.

To the Editor of Engineering.

Sir,—I have read with much interest your article on the designs for this bridge, and although as an engineer I cannot criticise, from an engineering point of view, designs put forward by members of our profession, yet I feel quite at liberty as a member of the public to give my views on the æsthetic side.

In the first place, let me say I am in accord with the writer of the article when he says in effect that there is, or may be, a profound difference between a



structure which (1) is obviously artistic, *i.e.*, pleasing to the generality of educated people, and (2) one which is "functionally" artistic, *i.e.*, beautiful only to those who are specially educated to view each part as essential to the stability of the whole. It is unfortunate that in a monumental work such as the bridge in question the site cannot be chosen to suit the bridge and not the bridge the site, as all the designs bear evidence of being cramped for space, and except Nos. 13 and 14, have a truncated appearance, and these two are so entirely on the side of "functional" art that they cannot be criticised except on expert engineering lines.

There is no doubt the arch (whether circular, eliptical or parabolic) is less severe in appearance than the straight line, and probably pleases the greater number, but we have numbers of ancient temples and our own Britannia bridge showing what can be done without the arch. Unless the arch can be supported by piers of substantial dimensions which are really assisting to support the work, it ceases to belong to category (1) and must be treated as coming under category (2), and in so doing may miss the essential æsthetic features of both.

Owing to my being merely one of the general public in this matter, I am without full details of the factors to be taken into consideration, but if the additional expense of arranging suitable curves of approach on the northern side is not great in comparison with the total expenditure, I venture to suggest a far more pleasing appearance would be obtained somewhat on the lines of the enclosed sketch, in which full advantage is taken of the arched form without introducing the "hybrid" appearance caused by mixing arched girders with horizontal approach girders and masses of masonry.

I have, &c.,
J. A. Saner, M.Inst.C.E.

Northwich, Cheshire, August 4, 1924.

PULVERISED COAL.

To the Editor of Engineering.

Sir,—In the eighteen-twenties George Stephenson proposed making a steam locomotive to draw passenger carriages at a speed of 12 miles per hour. Contemporary records indicate the amount of ridicule poured upon this innovation by many "Eminent Engineers" of the day, one of whom hoped "that he might not be confounded with those hot-brained enthusiasts who maintained the possibility of carriages being driven by a steam engine on a railway at such a speed as 12 miles per hour." The "Rocket" subsequently developed a speed of 29 miles per hour.

Stubborn ridicule is just as prevalent to-day as it was 100 years ago, and I personally experienced just such a deprecatory remark at the World Power Conference, a remark made by, I am thankful to say, an "Eminent British Engineer." The continued correspondence in the technical press about the "ash fallacy" in connection with the burning of pulverised fuel under steam boilers is, in my opinion, only wasting valuable space, for the vicious circle is making its appearance.

Just as the "Rocket" eclipsed the critics of its day, to such an end the plant increase of 5,000,000 tons capacity per annum of pulverised fuel during the past year or so, the outstanding bids for perhaps 2,000,000*l.* worth of further plant in America, the orders now placed for several stations in Great Britain and the unpreventable introduction of this "innovation" into the iron and steel industries, will prove to be self-evident confirmation of the claims reasonably put forward for the burning of fuel in pulverised form.

That progress in Great Britain in this direction cannot be stifled is plain when one considers that two of our engineering "Household names" are irretrievably committed to the courage of their convictions, else would they not have undertaken this doubtful process. I refer to Messrs. Vickers Limited, and to Messrs. Babcock and Wilcox, Limited. Moreover, progress in this direction and in the cause of general fuel economy is now likely to grow apace for, to use a Cabinet Minister's recent expression, the "wily politician" is likely to lend a hand.

If the "ash" from a boiler stack when pulverised coal is used is bound to be a general nuisance then one might reasonably ask why the Hammersmith plant has not been shut down? That a stoker-fired boiler plant can be a very decided nuisance in the discharge of grit from the boiler stack is on evidence in the injunction obtained of recent years against one of the London Borough Councils. No, Sir, conscientious advocates of the use of pulverised fuel have sufficient consolation in the fact that time alone can be the means of either converting or eliminating the obstructionist disbeliever, for this has been the experience through all the ages.

I am, Sir, Yours faithfully,
Leonard Harvey.

28, Victoria-street, Westminster, S.W. 1.
July 31, 1924.

Maximum Potential Gradients: Erratum.—In Major A. M. Taylor's letter on this subject published in our issue of July 25 last, on page 142, the diameter of the cable over the lead given near the bottom of the middle column as 5⅞ in., should have been stated as 4⅞ in. The error, however, is fairly obvious, since the diameter under the lead is correctly given as 4½ in.

Personal.—Mr. John Horne, A.M.I.E.E., who was for many years with the Metropolitan Vickers Electrical Export Company Limited, and the British Westinghouse Company Export Department, London, and latterly with the Westinghouse Electrical International Company, has now joined Messrs. Johnson and Phillips, Limited, as export sales engineer. His headquarters are at 12, Union-court, Old Broad-street, E.C.2.—On August 1 the Cardiff office of the Brush Electrical Engineering Company Limited, Loughborough, was transferred to 22, Dumfries-place, Cardiff. The telegraphic address ("Falcon," Cardiff), and telephone number (3464 Cardiff) remain unchanged.

Netherlands Prize Competition for Bridge Plans.—The municipality of Rotterdam have announced their intention to hold an international prize competition for plans for the reconstruction of the Koninginne Bridge, which spans the narrower of the two branches of the Maas River encircling Noorder Eiland in the city of Rotterdam. It should be noted that the competition is in no sense a call for tenders for the construction of a new bridge, but is instituted for the purpose of obtaining plans which could be utilised for the purpose of constructing a bridge. The first prize offered amounts to the sum of 10,000 guilders. British firms' plans may be drawn up in English. United Kingdom firms interested may apply by letter to the Department of Overseas Trade, 35, Old Queen-street, London, S.W.1 (Reference A.X. 1169), for a loan of the documents, which are in Dutch, and which will be lent in order of application.

Contracts.—The Vickers Spearing Boiler Company, Limited, of 20, Kingsway, W.C.2, have this week been successful in securing a large contract with the St. Pancras Borough Council for a complete boiler house plant, including pulverised fuel plant equipment for their electricity works.—We are informed that the D.P. Battery Company, Limited, of Bakewell, Derbyshire, have secured a contract for the supply of two batteries for the telephone exchanges at Gloucester and Newport the capacity in both cases being 4,993 ampere-hours at the 9-hour rate. Provision will be made so that the capacity of these batteries may be increased to 9,986 ampere hours and 8,812 ampere-hours respectively.—The London Midland and Scottish Railway Company have issued a list of the machinery orders they have placed with British firms between February 18 and June 30 this year. These orders amount in value to 120,089*l.*, and include a concrete mixing machine, a petrol-driven compressor plant, a large variety of machine tools, gas works plant, electric machines, &c.—The Power-Gas Corporation, Limited, Stockton-on-Tees, state that they have recently booked four contracts for three waste heat boilers for the Synthetic Ammonia and Nitrates Limited, Billingham; a coke gas producer plant for the same company; a coal gas retort generator plant with direct by-product recovery for the Yokohama Gas Works; and a complete gas power plant for Rhodesia.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The present industrial position all round continues to show weak features, with outputs substantially below those of four or five months ago. Manufacturers are hoping that the removal of the holiday influence will induce fresh interest in buying, and that efforts made over a long period to attract home and overseas consumers into the market will at least prove partially successful. Meanwhile evidence is afforded of the difficulties with which trade organisers are faced in their efforts to carry on. The closing down of steelworks at Bolton run by a Sheffield concern, and the intention of an old-established firm of tool makers to develop a business which they have purchased in Vancouver so that they may have an alternative base from which to operate should manufacturing conditions in this country become prohibitive, are disturbing signs of the times. The unequal operation of tariff policies also causes a good deal of anxiety. Business with British makers of automobiles, though still one of the most active sections of local industry, has declined some 30 per cent. to 40 per cent. since the Government decided to abolish the McKenna duties. A further blow at the special steel trade is aimed by the proposal of the French Government to revise its classification of tariffs. One of the most serious features of this contemplated revision is the suggestion that the duties on alloy steels shall be paid in gold, and not, as hitherto, in francs. This would mean an increase of approximately 200 per cent. in the case of mining machinery, spring steel, and fine tool steel, and so far as Sheffield's connection is concerned, would virtually put an end to business with French buyers. Movement in the heavy steel and engineering sections is still greatly restricted. Rolling mills are only operating intermittently on hand-to-mouth orders. An improvement in shipbuilding requirements is reflected in the conditions prevailing at the steel foundries, but production in the main is much below the capacity of the big plants. Tool makers are doing rather better. Producers of hack-saws, by paying special attention to quality, are making headway against American competition.

South Yorkshire Coal Trade.—While no further change of importance has been made in official quotations, the gross demand is anything but robust. Collieries are well able to meet requirements from outputs restricted by short time working. Business in the export of hard steams continues satisfactory, while the home demand inclines to be sluggish. Cobbles and nuts are a shade firmer than a fortnight ago, while there is a moderate market for best quality slacks. Gas coke is more active but furnace and foundry sorts are distinctly dull. Business in best quality housecoal has slightly improved. Quotations:—Best branch handpicked, 32*s.* to 33*s.*; Barnsley best Silkstone, 26*s.* to 28*s.*; Derbyshire best brights, 25*s.* to 27*s.*; Derbyshire best house, 23*s.* to 25*s.*; Derbyshire best large nuts, 21*s.* to 25*s.*: Derbyshire best small nuts, 15*s.* to 17*s.* 6*d.*; Yorkshire hards, 21*s.* 6*d.* to 22*s.* 6*d.*: Derbyshire hards, 21*s.* to 23*s.*; Rough slacks, 12*s.* 6*d.* to 15*s.* 6*d.*; Nutty slacks, 12*s.* to 14*s.*; Smalls, 8*s.* to 10*s.*

MURRAY RIVER BRIDGE TENDERS.—It is intimated that the New South Wales Department of Public Works have invited tenders for the manufacture, supply and delivery of metal work for one steel lift span, four steel truss spans, and steel superstructure for nine approach spans, for a bridge over the Murray River. United Kingdom firms in a position to supply British materials can obtain further particulars of this enquiry on application to the Department of Overseas Trade, 35, Old Queen-street, London, S.W.1, quoting reference A.X. 1175.

WAIKATO ELECTRIC POWER SCHEME.—A specification, with drawings, dealing with section 52, Spillway Regulating Gates at Wellington, New Zealand, for which the Public Works Department is inviting tenders, has been forwarded to the Department of Overseas Trade, 35, Old Queen-street, London, S.W.1, where copies may be had on loan, or be examined, by any British firms interested. The work consists in the supply and delivery of the whole of the metal work and operating mechanism, together with complete working drawings, for regulating gates of a spillway weir about to be built. Tenders will close on September 23, 1924.

CAVALLA HARBOUR ADJUDICATION.—It is announced by the President of the Cavalla Harbour Committee that an international tender will be invited for the construction of works according to specifications drawn up by the engineer, Mr. A. Ghinis. The estimated cost is 76 millions of drachmas (290,000*l.*). The adjudication will take place in the offices of the Harbour Committee, Cavalla, Greece, at 11 a.m. on December 1, 1924, and sealed tenders must be submitted by that date, accompanied by a certificate of the contractor's ability to carry out such works, this certificate to be signed by the Chamber of Commerce and the consular authorities, respectively. The guarantee deposit is Drs. 600,000 (2,300*l.*), and this deposit will be returned within three days of the decision to unsuccessful competitors. In the event of equal tenders, decision will be made by lot drawing. The carrying out of the works will be under the supervision of the Harbour Executive Committee, with whom the contractor will negotiate. The decision of the Harbour Committee must be ratified by the Ministry of Communications. Full details of requirements can be seen at the offices of the Harbour Commission, Cavalla, and also at the Municipal Offices and Chambers of Commerce at Athens and Salonica.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Cleveland pig iron stocks at makers' works are rather large, but, though customers are not taking out full supplies, the accumulations are stated to be very well sold. At the same time production is now more than sufficient for current needs, and consequently some apprehension is felt as regards the future. Home sales are on only a moderate scale, and export markets are closed to this district by the comparatively cheap Continental iron offered to customers abroad. Quotations continue to follow a downward course. No. 1 is 90*s.*; No. 3 g.m.b., 85*s.*; No. 4 foundry, 84*s.*; and No. 4 forge, 83*s.*

Hematite.—The statistical position in the East Coast hematite branch is unsatisfactory. Stocks are heavy and are steadily increasing. Foreign competition cannot be met. French hematite is reported selling abroad to firms that used to draw considerable supplies from this district at about 10*s.* per ton below figures at which makers here can offer iron. Prospects are very discouraging. Whilst producers are reluctant to follow fall in values further drop is threatened. Nos. 1, 2 and 3 are weak at 94*s.*; and No. 1 is put at 6*d.* above mixed numbers.

Foreign Ore.—Imported ore is extremely slow of sale, and it is difficult to ascertain on what terms contracts might be arranged. Sellers still base market quotations on best rubio at 23*s.* c.i.f. Tees.

Blast Furnace Coke.—Durham blast Furnace coke prices are easy. Good medium qualities are offered freely at 26*s.* 6*d.* delivered to local users.

Manufactured Iron and Steel.—Steel makers are running at full capacity, and are so heavily booked that they hesitate to negotiate for further deliveries this year. The export price for galvanised corrugated sheets (24 in. gauge), in bundles, is now fully 18*l.* 10*s.* Some firms are fairly busy on shipyard specifications, and a few orders for steel rails are reported, but in most other branches manufacturers are getting well through work on hand, and they experience considerable difficulty in securing orders to follow on fast expiring contracts. Export prices vary a good deal, but the following rates are still named for home business: Common iron bars, 12*l.* 10*s.*; iron rivets, 14*l.* 5*s.*; packing (parallel), 9*l.*; packing (tapered), 12*l.*; steel billets (soft), 8*l.* 10*s.*; steel billets (medium), 9*l.*; steel billets (hard), 9*l.* 10*s.*; steel boiler plates, 13*l.* 10*s.*; steel ship, bridge and tank plates, 10*l.* 5*s.*; steel angles, 10*l.*; steel joists, 10*l.*; heavy steel rails, 9*l.*; and fish plates, 13*l.*

Shipments of Iron and Steel.—Official returns give the July shipments of iron and steel from the Tees ports at 73,686 tons, 32,524 tons being pig iron, 1,737 tons manufactured iron, and 39,425 tons steel. Of the pig iron shipped 20,161 tons went abroad, and 12,363 tons went coastwise. Of the manufactured iron loaded 945 tons went overseas, and 792 tons coastwise, and of the steel despatched 31,580 tons went to foreign destinations, and 7,845 tons coastwise. Scotland with an import of 9,061 tons was the largest customer for pig iron, and among the other principal receivers were Belgium, 5,705 tons; Italy, 3,491 tons; France, 2,519 tons; Germany, 1,975 tons; and Denmark, 1,795 tons. Hong Kong was the biggest buyers of manufactured iron, taking 325 tons. India was, as usual, the heaviest purchaser of steel, receiving 9,287 tons; whilst Hong Kong imported 2,972 tons; Japan, 2,367 tons; New South Wales, 2,039 tons; Victoria, 2,034 tons; the Argentine, 1,709 tons; Natal, 1,545 tons; Egypt, 1449 tons; and Kenya, 1,300 tons.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The state of the steel trade in Scotland at the present moment is not encouraging, and the outlook is far from satisfactory. The delay in re-opening a number of the works after the holidays would seem to be justified because of the poor demand on the part of buyers. There have been few contracts placed during the past few weeks, and inquiries even have become scarcer. Specifications from shipbuilders are not as good as they were expected to be at this time, and although an improved demand was considered a certainty by the close of the holidays there are few indications of this yet. A change for the better may take place in the near future, but general conditions do not meantime point to this much-wanted improvement in business. The brightest side of the industry is still black and galvanised sheets for which there are again good inquiries in the market. Delivery before the closing months of this year can scarcely be promised by any of the makers so well are they booked forward. The price also shows a hardening tendency and galvanised sorts have already been rising. The following are to-day's market quotations:—Boiler plates, 13*l.* 10*s.* per ton; ship plates, 10*l.* 5*s.* per ton; sections, 10*l.* per ton; and sheets ⅛ in. to ½ in., 12*l.* 10*s.* per ton, all d/d. Glasgow stations.

Scottish Pig-iron Trade.—A dull tone is general in the Scottish pig-iron trade, and foundry grades in particular are very quiet, but a few inquiries are in circulation. The actual demand is extremely poor and there is not much sign of any buying movement yet. Hematite iron is just moving slowly and there is only a limited demand. Prices continue weak and the following may be taken as to-day's quotations:—Hematite, 4*l.* 16*s.* 3*d.* per ton, d/d. at the steel works; foundry iron, No. 1, 4*l.* 18*s.* 9*d.* per ton, and No. 3, 4*l.* 13*s.* 9*d.* per ton, both on trucks at makers' yards.

Malleable Iron Trade.—No change of any kind has taken place in the West of Scotland malleable iron trade during the week and the outlook is still very uncertain. There seems to be little disposition on the part of buyers to come into the market and inquiries are also of a very meagre description. Quotations are being maintained, and "Crown" bars are called 12*l.* 10*s.* per ton, d/d. Glasgow stations.

Shipments of Scottish Pig-Iron.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, August 2, amounted to 635 tons. Of the total, only 190 tons went overseas and the major portion of 445 tons went coastwise. For the corresponding week of last year 1,312 tons went overseas and 138 tons coastwise, making a total shipment of 1,450 tons.

Shipbuilding.—The shipbuilding returns for the past month are rather below the average monthly output for the other six months of the year, and, with the exception of last year, are under the average July figures since the war. This is somewhat disappointing, when it was thought that the industry was gradually improving. The following is the output of new tonnage from the various districts in Scotland for the month of July:—

	Vessels.	Tons.
The Clyde	15	27,835
The Forth	1	2,775
The Tay	3	2,900
The Dee and Moray Firth ...	—	—
Total	19	33,510

While the Clyde figures are the second lowest monthly output this year, they help to bring up the year's total to 133 vessels of 282,202 tons, which is the highest tonnage for the first seven months of any year since 1920. This in itself is satisfactory, and is always tending in the right direction. On the other hand, the number of new contracts placed during the past month has not been at all satisfactory, and less than half a dozen have been reported. Labour troubles in the industry are smoothing themselves out and this may have some influence upon the placing of fresh orders, but a speeding up in the giving out of new contracts would be most acceptable.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—With work in the South Wales coalfield and the docks at a standstill for half the week because of the intervention of the August Bank Holiday the Cardiff Coal and Shipping Exchange was also closed and new business was virtually at a standstill. It is, however, hoped that the loss in production occasioned by the holidays would have a steadying effect on prices which generally were on the basis of 28*s.* to 28*s.* 6*d.* for best Admiralty large, 23*s.* 6*d.* to 27*s.* for Monmouthshires, 25*s.* to 27*s.* for drys, 50*s.* to 52*s.* 6*d.* for Big Vein large anthracite, 57*s.* 6*d.* to 60*s.* for French anthracite nuts, and 12*s.* to 17*s.* for steam smalls, according to quality. Exports of coal as cargo last week amounted to 467,590 tons compared with 487,290 tons in the previous week. Shipments from Cardiff totalled 289,640 tons against 314,230 tons, from Newport 87,230 tons against 66,660 tons, from Swansea 61,870 tons against 46,130 tons, from Port Talbot 24,210 tons against 54,570 tons and from Llanelly 4,630 tons against 5,700 tons. Exports to France amounted to 175,170 tons against 162,460 tons, to Italy 44,910 tons against 100,330 tons, to South America 95,820 tons against 70,530 tons, to Spain 28,980 tons against 36,020 tons, and to Portugal 36,190 tons against 14,620 tons.

Big Anthracite Combine.—There is good reason for stating that a movement is on foot for an amalgamation of the present two big anthracite combines together with two of the largest independent companies. At the moment the scheme is in an initial stage and details have not leaked out. The two public combines are the Amalgamated Anthracite Collieries, Limited, with an issued capital of 1,789,507*l.*, of which Sir Alfred Mond, Bart., is chairman, and the United Anthracite Collieries, Limited, with an issued capital of 1,675,000*l.*, of which Sir Samuel J. G. Hoare, Bart., is chairman. The output of the two companies is about 1,500,000 tons per annum, which represents nearly 40 per cent. of the total yearly anthracite production of South Wales.

20,000 KW. TURBO-ALTERNATOR FOR WHITE BAY POWER HOUSE, NEW SOUTH WALES.—The office of H.M. Trade Commissioner at Sydney reports that the New South Wales Government Railways and Tramways Department is calling for tenders, to be presented by October 15, for a 20,000 kw. turbo-alternator. Copies of the specification, general conditions of tender, and blue prints can be inspected by British firms at the Department of Overseas Trade (Room 52), 35, Old Queen-street, London, S.W.1.

HYDRO-ELECTRIC PLANT FOR MENDOZA, ARGENTINE.—The Commercial Secretary at Buenos Aires reports that the Argentine National Sanitation Works Department are calling for tenders, to be presented by October 6, for the supply and delivery of machinery for a hydro-electric station to be installed in the town of Mendoza. The plant required includes horizontal turbines, 3-phase generators, switchboard, pipes, &c., and spares. A copy of the specification and conditions of tender, in Spanish, can be seen upon application at the Department of Overseas Trade (Room 52), 35, Old Queen Street, London.

ELECTRICAL RECORDING INSTRUMENTS; BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. EVERETT, EDGCUMBE AND CO., LIMITED, HENDON.

(*For Description, see Page* 207.)

Fig. 1. Switchboard Type Recording Power Factor Meter.

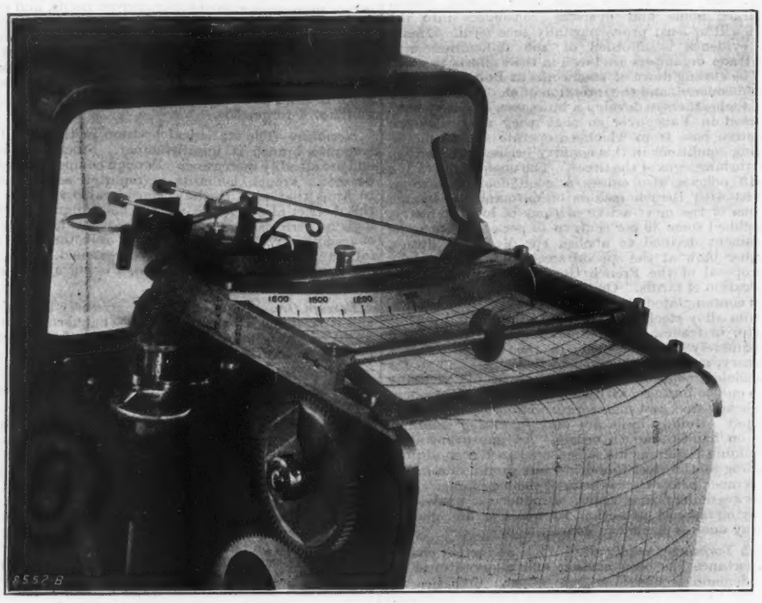


Fig. 2. Pen Mechanism of Recording Power Factor Meter.

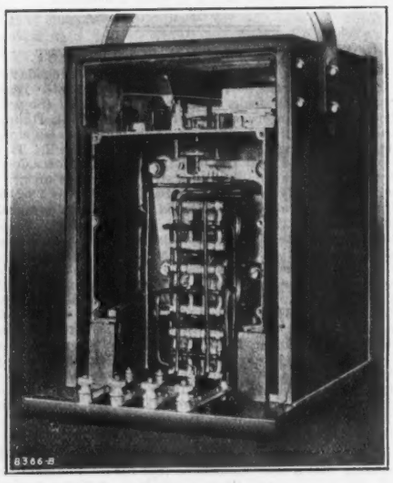


Fig. 3. Portable Recording Power Factor Meter.

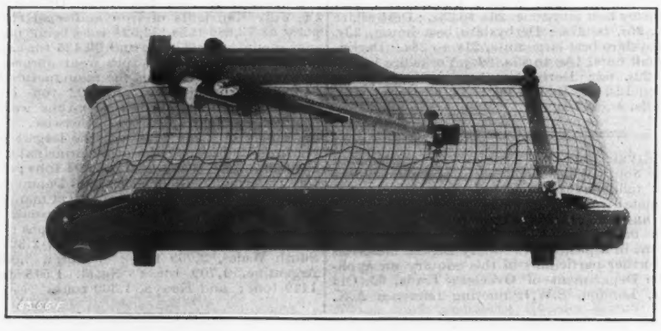


Fig. 4. Planimeter for Averaging Record Charts.

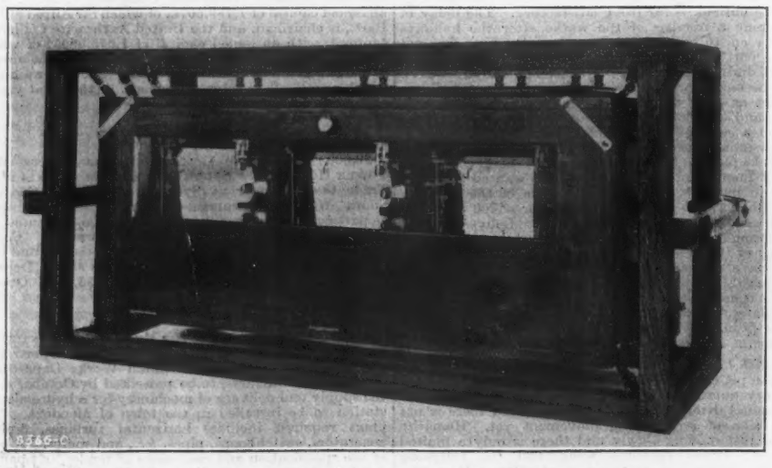


Fig. 5. Recording Instruments for Electric Traction Work.

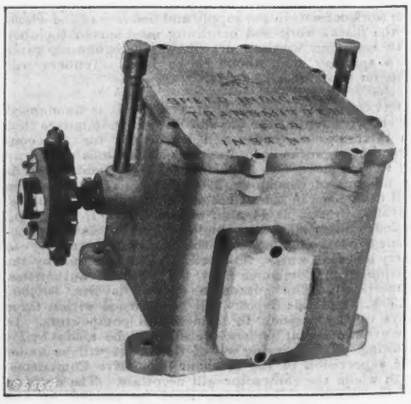


Fig. 6. Transmitter for Speed Indicators and Recorders.

THE CABLE-LAYING STEAMER "EDOUARD SUENSON" FOR THE GREAT NORTHERN TELEGRAPH COMPANY OF DENMARK.

CONSTRUCTED AT THE ROYAL DANISH DOCKYARD, COPENHAGEN, DENMARK.

(*For Description, see Page* 196.)

Fig. 2. ELEVATION.

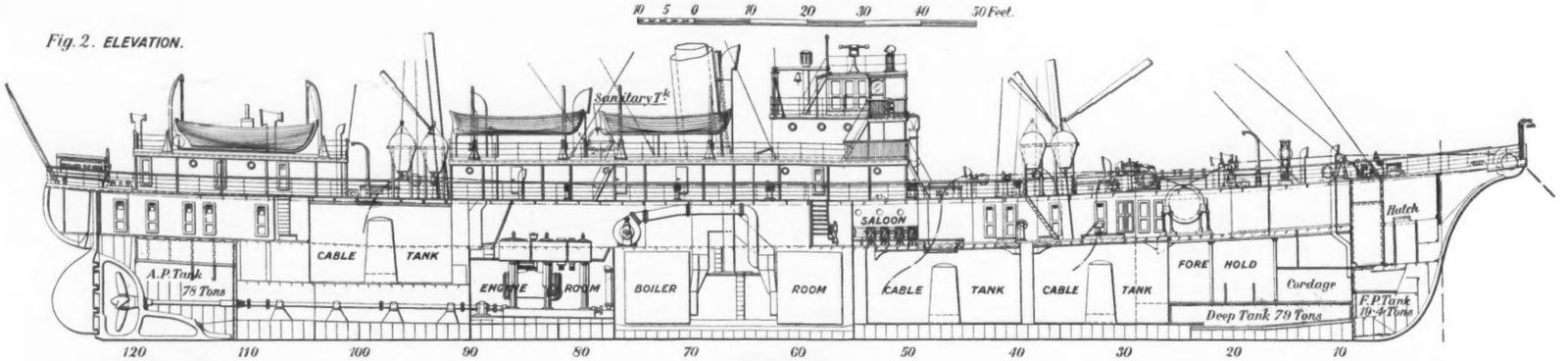


Fig. 3. AWNING DECK.

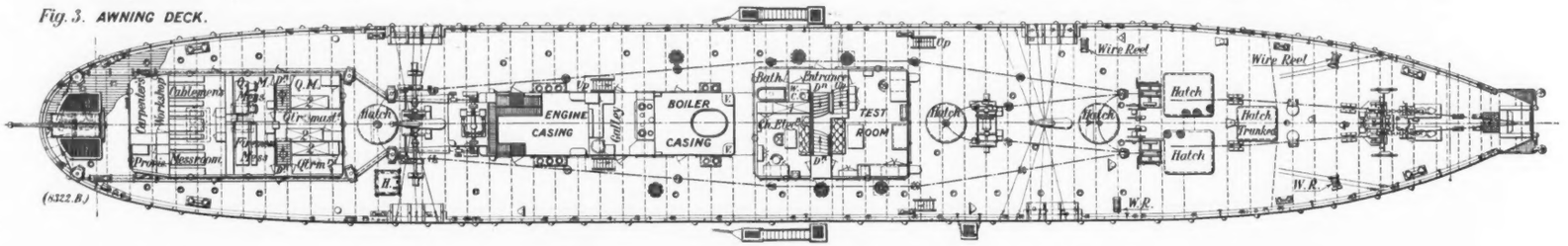
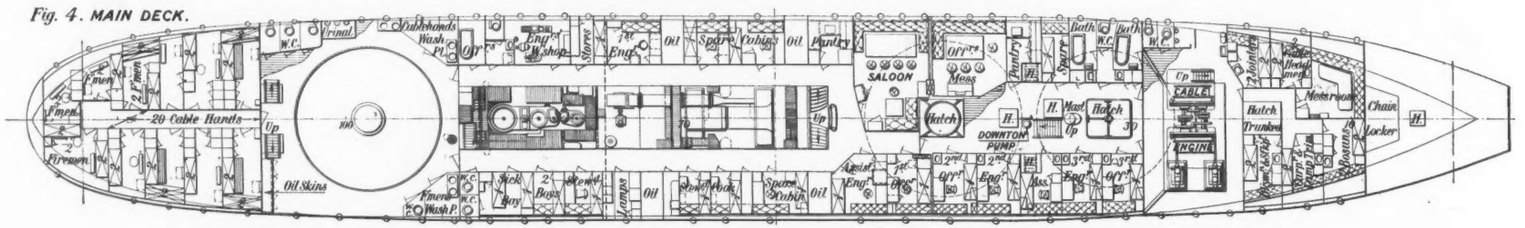


Fig. 4. MAIN DECK.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Wash Pl.
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Firemen
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Wash P.
Jack Buoy
Boats
Stores
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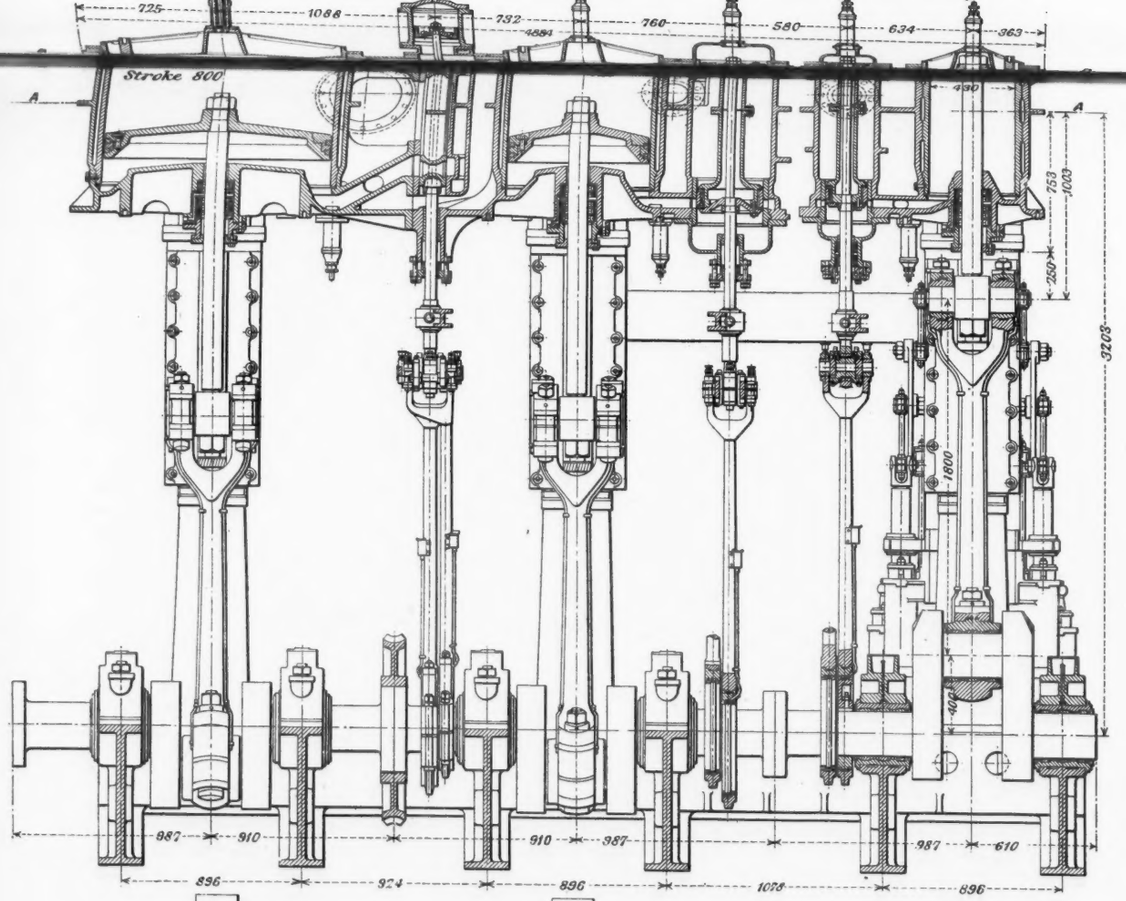


Fig. 7.

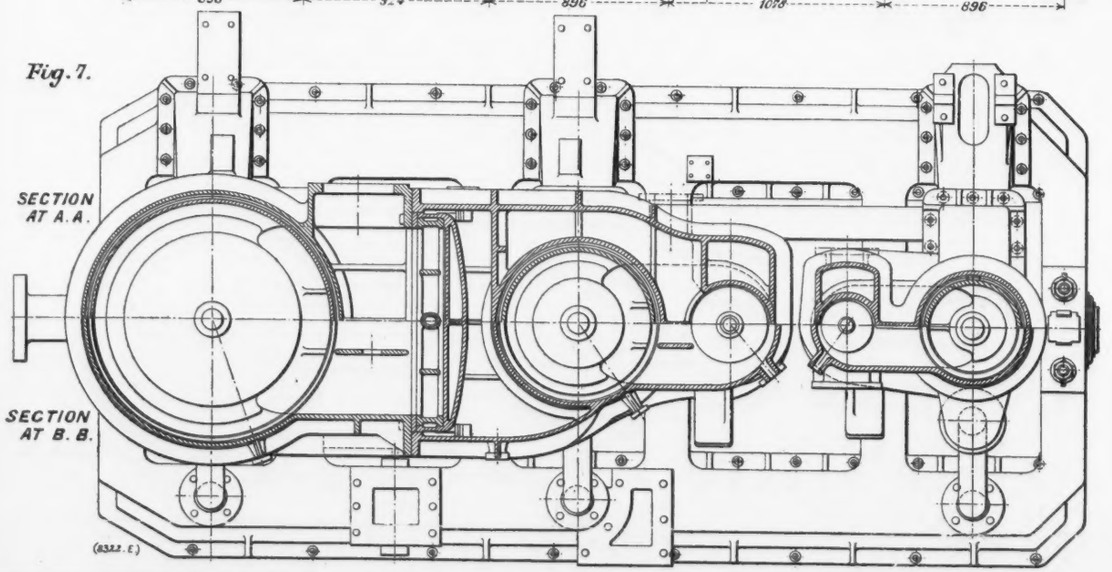


Fig. 8.

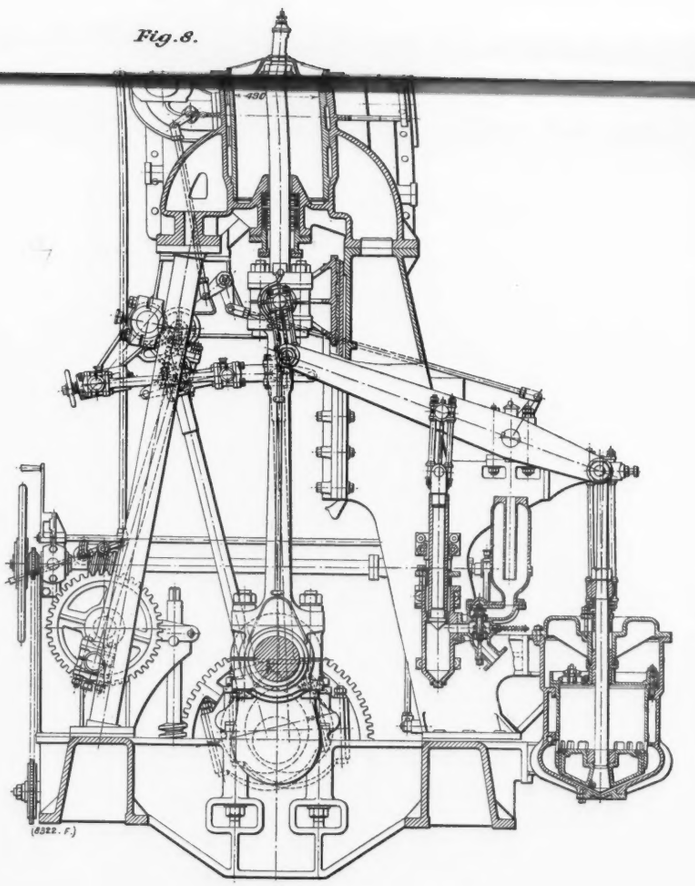
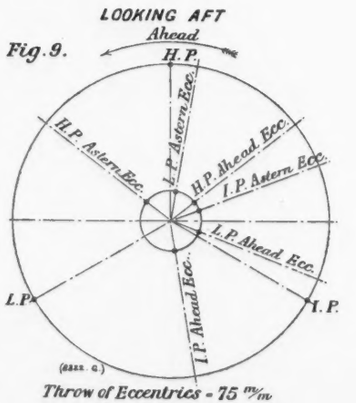


Fig. 9.



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ENGINEERING.

FRIDAY, AUGUST 8, 1924.

MECHANICAL ENGINEERING AND THE WAR OFFICE.

IT is a matter of common knowledge that the mobilisation of our industrial resources during the late war left a great deal to be desired. Plans had been prepared beforehand by military experts for the concentration of troops, the calling up of reserves and the enlistment and training of recruits which would be necessary in case of serious national emergency, and on the whole these plans worked satisfactorily. The professional soldiers knew their business and expanded our fighting strength from its almost insignificant nucleus into an army of millions in a manner which left little to be desired. To enable such an army to carry on warfare under modern conditions necessitated an equally great and sudden expansion of our munition-making resources, and this, the military authorities were quite unable to organise. They had neither the mechanical knowledge nor the experience of manufacturing conditions essential to the performance of a task demanding qualifications totally different from, but in no way inferior to, their own. The tragic shortage of shells in the early part of the war led to the formation of the Ministry of Munitions, whose duty it was to make good this defect in our organisation and relieve the military authorities from work which they did not understand. Their actions were often rightly criticised by engineers but they eventually attained their end, and the blame for the cost at which it was reached must be looked at in the light of the confusion existing from the lack of any scheme thought out in advance.

It was hoped and, indeed, confidently believed, that the experience of trying to get a sudden and satisfactory output of totally unfamiliar products from firms without the necessary tools, jigs, gauges or knowledge for the purpose would have taught the Army Council the obvious lesson, namely that the permanent staff must comprise engineers with a status and authority sufficient to ensure that such conditions should never occur again. But with the coming of the Armistice and the subsequent dissolution of the Ministry of Munitions the importance of engineers and their work to national defence appears to have been forgotten, so far as can be judged by the absence of their adequate representation in the army organisation. The military man, pure and simple, will never be able to mobilise the resources of industry, for he knows nothing about industry, and even less is he fitted to make the detailed and comprehensive plans which must be prepared in advance, if the immediate assistance of private firms is to be relied on for urgently needed munitions.

In the case of the last war it is poor satisfaction to ourselves to know that a similar lack of prevision with regard to munitions, found the United States unable to equip their own armies, when they undertook hostilities. They had mechanics, skill and machines in abundance, and repetition work was a feature of their engineering industry, yet they failed as badly as we did in getting the immediate production of unfamiliar products which the army demanded. The reason was the same on both sides of the Atlantic namely the lack of any scheme for mobilising manufacturing resources to the best advantage. The Americans have learned their lesson, at any rate partially, and remote as is the probability of another war the American War Department has taken steps to ensure that the industrial mobilisation of the United States shall be prompt and effective. The scheme is based upon the division of the country into fourteen areas, according to nature and density of population. In each district such manufacturers as will be required to participate in the war programme, are provided with drawings, specifications and information on the production of the items assigned to them, so that when required by the War Department they can turn over directly to munitions. Every district also contains the nucleus of a munitions committee, consisting of a prominent business man who serves voluntarily, a regular army ordnance officer and a clerk.

The sensible and thorough way in which the United States are taking steps to protect themselves against a munition crisis in any future war were well indicated in a paper, entitled "The Role of the Engineer in Industrial Mobilisation Planning," read by Capt. E. E. MacMorland, of the United States Ordnance Department, at the recent spring meeting of the American Society of Mechanical Engineers at Cleveland, Ohio. Capt. MacMorland, not only had war service in France and Russia, but was awarded the D.S.O. from our own Government for conspicuous service. His present duty is concerned with the plans for the mobilisation of industry discussed in his paper, the object of which is primarily to enlist the co-operation and goodwill of the American Society in the work which he has at heart. His case, which is, of course, that of the American military authorities, is presented so clearly and convincingly that no doubt can exist as to the appreciation of the central facts of the position on the part of the American War Office. They look to industry to supply 95 per cent. of the munitions required in any future war, and appear to be adopting the only efficient method of ensuring that they shall be forthcoming when wanted.

Capt. MacMorland's paper deserves the close attention of all who are interested in the defence of this country, for his arguments are equally applicable here. He points out that the knowledge of munition making is disappearing, the men who were skilled in it are passing away, and the records of the methods employed are fragmentary. The preservation of particulars as to the details of manufacture adopted by the most successful munition firms has been recognised as of the greatest importance, and the American Ordnance Department is gathering and collating this information. The final result will be the preparation of a series of books giving the fullest possible particulars of every process, together with details of the machines, fixtures, tools and gauges used, and the speeds and feeds found most effective. There will be a book dealing with the manufacture of every major item of munitions. We have more than once advocated the preparation of exactly similar books by our own authorities, but their value does not seem to be appreciated by the regimental mind. It is, however, realised by the Americans that such books cannot

fail to start the war contractor of the future on his production work with the least possible delay and experimentation. The American Society of Mechanical Engineers are invited to criticise these books as they appear, so that every edition shall embody the best and latest practice.

The preparation of such books giving details of recommended manufacturing processes for all munitions wanted in quantity, would not only enormously expedite output in the early days of a war but the cost of their production would be insignificant in comparison to the financial savings they would effect. Not only would they enable a firm to know exactly how to set about the manufacture of the articles required without wasting valuable material and invaluable time in trying all kinds of ineffectual methods, but by giving the standard times required for the performance of every operation required to produce the finished article they would necessarily provide simultaneously standards of output and cost. If a firm did not feel in a position to quote a firm price for a quantity of some unfamiliar articles, the Government would be in a position to say "If you choose to adopt the methods which are here described in detail, your output will be so many per machine per week, and consequently we will pay you so much per piece and no more. If you can improve on the methods suggested you are free to do so." Such a procedure would be infinitely more businesslike and efficient than the demoralising practice too often adopted during the late war, namely, that of paying "time and line" or cost plus so much per cent., which was almost a direct incentive to waste and inefficiency.

In addition to assisting manufacturers to get into quick and efficient production, the American scheme provides for munition work to be carried out with a view to the minimum transportation of raw and finished material. We in this country have had experience of trainloads of billets for 12-in. shells, each weighing half a ton, being sent from Glasgow to London to be forged, back to Newcastle to be machined and then possibly to South Wales to be filled, all on their way to France.

The great waste of time and labour in handling and the strain on the depleted staff of our congested railways which all such to-and-fro transportation involved could mostly have been avoided by forethought in time of peace, such as the Americans are giving to the problem. The American military authorities are also asking advice from manufacturers with regard to specifications and designs, with a view to approaching commercial standards as nearly as possible, knowing that the less uncommon are the requirements the greater the chance of quick and satisfactory production by ordinary firms.

We have said enough to show how earnestly the Americans are endeavouring to profit in the future by the lessons of the war-period. The cost of their plan is not great, and, indeed, is negligible, beside the saving it will bring about if ever another war is declared. The more exposed and vulnerable position of this country makes equally intelligent preparation for the rapid mobilisation of industry even more imperative. No reasonable person anticipates another war, but very few reasonable people, even in positions of special knowledge, seem to have anticipated the last. There is no harm in being ready to protect ourselves, and the most ardent pacifist could find nothing provocative in a plan for making use of our defensive resources in the most efficient way. The preparation of such a plan can only be properly carried out by men with full knowledge of manufacturing problems and industrial conditions; in other words, by experienced mechanical engineers. The Army fortunately for itself still contains a few such men, but in the absence of any professional outlook in the Service they are a diminishing quantity. Until the mechanical engineer is recognised as distinct and necessary a part of the Army organisation as the Medical Officer or the Veterinary Surgeon, and like them can attain a rank and authority commensurate with his responsibilities, we can only trust that the military defence of the country will never be put to the supreme test.

REGULATIONS FOR THE ELECTRICAL EQUIPMENT OF BUILDINGS.

In the early days of the use of any improvement in lighting, heating and power, consideration was not always given to the important question of safety. Only after troubles were experienced were any endeavours made to ensure that in the future the faulty arrangements which made them possible, would not be tolerated. Ever since the earliest times, however, when electricity was applied to practical work in domestic and industrial buildings, electrical engineers showed forethought in estimating the potentialities of danger and made preparations to prevent their developing. It is true, however, that wiring work was not always undertaken by men with a thorough knowledge of electricity and its effects and consequently rules had to be formulated to which compliance was essential before an electricity supply could be obtained. The Institution of Electrical Engineers gauged the requirements in the then existing state of knowledge, and prepared, as far back as 1882, their first publication on the subject, which was entitled "Rules and Regulations for the Prevention of Fire Risks arising from Electric Lighting." Modifications of these were issued at various times as progress was made and new developments necessitated the extension of the rules. Since 1916 these wiring rules have until now remained unchanged except for an amendment made in October, 1919, relating to cables which were then specified in terms of the number and actual diameter of each wire rather than by the Standard Wire Gauge. This modification was made when the standardising authorities decided upon the reduction of the number of standard sizes. The fire insurance companies and the supply undertakings were also interested in the question of safety of electric installations and formulated rules of their own. In consequence of the multiplicity of rules which had to be adhered to in any specific installation it was, of course, necessary to meet the most rigid requirements of the series for every part of the installation. Under such conditions it soon became evident that a unification of rules was essential and an endeavour was made to meet the requirements of all. Where interests were so conflicting, compromises were necessary. The work has, however, been successfully accomplished, and this is evident from the new set of rules now made available to the electrical public. These are embodied in a publication with the title "Regulations for the Electrical Equipment of Buildings," which is now obtainable from Messrs. E. and F. N. Spon, Limited, of 57, Haymarket, London, or from the Institution of Electrical Engineers.

The new rules have been adopted by practically all the large insurance companies and such organisations as the Incorporated Association of Electric Power Companies, the Incorporated Municipal Electrical Association and the Provincial Electric Supply Committee of the United Kingdom, which represent the supply undertakings. It is a matter for congratulations that this unification has been obtained, and credit must be given to the men who were responsible. In this respect special mention must be made of the valuable services of Mr. C. H. Wordingham as Chairman and of Mr. Ll. B. Atkinson as Vice-Chairman. It should be said that the I.E.E. Wiring Rules Committee, which carried through the scheme, was not made up entirely from the Members of Council of the Institution, but was largely composed of representatives of the various sectional interests. No sectional interest was left out and, consequently, success was ensured. Details may require modification as experience grows, but it must be acknowledged that the work has been thoroughly well done. We note in the regulations that if it is desired at any time to use cables insulated in ways other than those specified, tests of samples, by such authorities as the National Physical Laboratory, must be submitted for consideration by the Institution of Electrical Engineers, with a view to their use being permitted, if found satisfactory. As it is impossible to forecast with absolute accuracy the lines of any new development, we are glad to see this statement included, but we trust that some means will be preserved of bringing the various authorities together to ensure general recognition of the findings, by all the interests involved. Not only in cables may changes be anticipated, and therefore, similar provisions should be incorporated which will permit the early framing of regulations for the use of any improvements which might be made in connection with any item in a complete installation.

As the regulations are not merely a modification of the old I.E.E. Wiring Rules, but embody many matters on which the fire insurance companies have stronger views than those held by many electrical engineers, it serves but little purpose to make comparisons between the old rules and the new. All that is necessary is to take the rules as they are, and no one can study them without appreciating the care taken in ensuring that absolute safety will result from their application. From now we have one set of rules only, and if they are complied with the various authorities interested will accept the work as meeting their individual wishes. The study of the rules in detail shows up one thing strikingly, that there are many old installations to which supply is at present given which comply with no reasonable standard of safety requirements. A close reading of the regulations will cause surprise to many people, regarding the faulty arrangements which are present in their electric installations and that knowledge may help them to decide whether the risks entailed, or the extra insurance premiums which must be paid, are comparable with the small expense involved in ensuring perfect safety.

THE LATE SIR GEORGE BEILBY.

We regret to record the death of Sir George Beilby, F.R.S., which took place at his house at Hampstead on the 1st inst. He had been ill for some little time, but the seriousness of his illness was not realised until shortly before he died. He was born in Edinburgh in 1850, and was thus in his 74th year.

Educated privately and at Edinburgh University, George Thomas Beilby went into the service of the Oakbank Oil Company in 1869, and from then was engaged continuously in technical industry, until he retired from it early in the war through pressure of national work. To the general public, and perhaps even to most of our readers, he was best known by what he did in the last ten years of his life; but, eminent as were his public services during that period, his previous career had been distinguished and successful alike in his private and his public activities. His chemical knowledge and insight enabled him to introduce into the Scottish shale oil industry improvements in the processes of distillation, such as that by which he converted spent material into a valuable source of ammonia. He made prolonged investigations about the same period into the distillation of shale at a relatively low temperature in a current of steam. Little profit was obtainable on each product and success depended on cumulating the small profits on a well-balanced aggregate of useful commodities. He was not less successful in the other industrial enterprises with which he was associated, notably the Castner Kellner and Cassel Cyanide Companies; and as far back as 1910 he was engaged in experimenting at the Maryhill works of the latter company on carbonising coal at from 400 to 500 deg. C. and on briquetting the coke.

His private industrial enterprises and technical work did not, however, exhaust his energy and interests, though in many matters they added special authority to his influence. He became, for example, a prominent and trusted supporter of the Glasgow and West of Scotland Technical College, which in 1886 amalgamated Anderson's College, the College of Science and Arts—the first Mechanics' Institute in the country—and the Atkinson Institution. He was a governor of this ancient foundation up to his death, and its chairman for many eventful years, during which it became in 1912 the Royal Technical College, Glasgow, and in 1913 was affiliated to the University of Glasgow. It is housed in buildings that provide over 7 acres of floor space, and with equipment cost some £400,000, and it has a development fund of over £60,000

for the prosecution of research. The buildings are well equipped and provide facilities for the work of the College unequalled in Great Britain, especially in the Engineering and Technical Chemistry Departments. Last year, in its 127th session, it was attended by over 1,200 day students and over 5,000 evening students, of whom the majority were over 19 years old. It is no secret that in all this remarkable development, even to the skilful designing of the new buildings by which the natural difficulties of the site were not only faced but turned to useful account, the College was indebted to Sir George more than to any other individual. Apart from his personal contributions from his own means, he gave it without stint unwearied labour, unfailing tact in prolonged and sometimes difficult negotiations, and the benefit of his wide experience of scientific and industrial matters.

The scope of the College is by no means confined to Glasgow, for over half its day students and nearly a third of its evening students come from other parts of Scotland, and over 100 come from England and other parts of the world. Sir George did not confine his public activities to the College. Apart from his personal work in chemistry and microscopy, he had wide scientific interests, and when in 1900 the National Physical Laboratory was instituted, under the control of the Royal Society and the direction of Sir Richard Glazebrook, he was a member of its first committee, and exerted an active and useful influence in procuring for it a fair start. He was also on its committee when its administration was taken over in 1918 by the Research Department, and remained a member until his death. In 1903 he reported at some length to the Royal Commission on Coal Supplies, with considered and valuable estimates of consumption of coal in the several services in which it is used, and of the order of magnitude of the economies that seemed possible in each by the adoption of improved methods. He was a member of Lord Fisher's Commission on Fuel and Engines for the Navy in 1912–13. Though he was thus a well-known figure in scientific and administrative circles in London, his chief work was done and his life and recreation were centred in Glasgow, until he became absorbed in the public duties that he assumed during the war.

His help in war matters seems to have been asked on the occasion of the first gas attack, when the leaders of German civilisation introduced the use of poison into international warfare. He gave it immediately and ungrudgingly. All the wide manufacturing knowledge that he possessed or that was among the trade secrets of his companies was placed unreservedly and without charge at the disposal of the Government. With Sir Joseph Thomson and Sir Charles Parsons, he became a member of Lord Fisher's Board of Inventions and of the Trench Warfare Committee. In 1915 when the Privy Council set up its Committee for Scientific and Industrial Research, and he was asked to act as one of its first members, he gave up his Glasgow home and for the rest of the war and long after resided in a London hotel. From the outset his work, especially on trench warfare, occupied seven long days a week; but the fuel situation was causing the Government the gravest anxiety, and Lord Crewe, just before his retirement, in 1916, from the Presidency of the Privy Council, asked him to undertake the organisation of the Government's fuel programme on a national basis, instead of leaving it to the uncoordinated co-operation of the industries. No man saw more clearly than Sir George that even the results of co-operative research would be of small service to the great industries unless the fuel position were put on a sound basis. When to this assured general conviction was added the urgent need for home supplies of fuel oil for the Navy, he recognised that the subject was of much greater importance to the safety of the country even than those on which he was engaged, and accepted the Government's invitation to become chairman and director of a Fuel Research Board, of which Sir Charles Parsons, Sir Richard Redmayne, and Sir Richard Threlfall were to be the other members. The institution of the board was followed rapidly by the decision to erect the Fuel Research Station, in the design every detail of which Sir George was personally concerned. Within a year of its completion he had worked out to a practical result his method of making coals from unsuitable seams serviceable for low-temperature carbonisation by blending them in appropriate mixtures, and had produced a retort in which, effectively if not economically, the method could be applied in practice. The end of the war made it unnecessary to apply it; but the result of this work was that, if the war had continued, the whole of the coal supplies could have been converted into low-temperature coke before being used, and a large part of the fuel oil required by the Navy could have been supplied without importation.

It is hardly necessary in these columns to recite again the work that the Fuel Research Board has done through Sir George Beilby's inspiration. The need for fuel oil was, indeed, the immediate occasion of its inauguration, and it is still pursuing both the scientific and practical investigations, and the

Photograph by Elliott and Fry.

THE LATE SIR GEORGE BEILBY.

qualitative as well as quantitative survey of national coal resources that he initiated. But, as has appeared abundantly in these columns from time to time, the Board's work extended to many other subjects—carbonisation in vertical retorts with steam and the sale of gas by its heating value, are prominent examples—and his work extended to details as well as to the original conception.

Part, indeed, of his personal equipment was his rare ability to combine a wide and sensitive imagination with a tenacious and clear-headed attention to the practical details by which it might be made use of in the best possible way. This doubtless was a valuable gift, but it imposed on him a vast amount of work that men of less ability would not have undertaken. It seems, however, to have been directly responsible for the unusual success that attended his work in the many varieties of activity he undertook. It involved, of course, a strict economy of his personal time. He was a distinguished microscopist, whose investigations led him to the theories of the aggregation and flow of solids, developed in well-known papers and re-stated in 1921 in his work under that name. These theories are in part accepted and in part controversial; but the microscopic work from which they resulted was adopted as one of his pursuits, because it could be fitted in to odd intervals of his other occupations. He was an accomplished musician, distinguished by singular expression as an executant; he built his organ—all but the pipes—with his own hands, and when recently he disposed finally of his Glasgow house and set up his new home in London, he took the organ down himself, and had already begun to re-erect it and to add to the many devices with which he had graced it when he was taken ill. Incidentally, he was an expert in colour photography, an art in which his natural sense of beauty led him to remarkable results.

A notable feature of the great work he did during the last nine years was the fact that he did not accept any sort of remuneration, or even the reimbursement of his personal expenses. On the contrary, the trade information that he gave and the patents he took out were all transferred to the Government gratuitously. He was often to be seen on bitterly cold mornings sitting with a principal officer of the Research Department in a Greenwich omnibus on his road to the Research Station, because he declined to allow a Government car to be placed at his disposal, or even to use his own because of the scarcity of petrol. He had a sensitive appreciation of the abilities and aspirations of other men, and incidents without number have leaked out—for on such matters he was utterly reticent—testifying to the generous sincerity with which he would give help in every form to those to whom he thought it would be of service and to movements for their benefit.

Knighted in 1916, he was a Doctor of Laws of Glasgow and Birmingham, a Doctor of Science of Durham, a past president of the Society of Chemical Industry, the Chemical Section of the British Association, of the Institute of Chemistry, and of the Institute of Metals, and an Associate Member of the Institution of Civil Engineers. He died within a few days of the announcement that the Government had decided to press on with the coal survey he had instituted and with the testing of promising plant in private hands, as is now known, by an additional grant of 30,000*l.* on next year's estimates. By a coincidence, the first visit of a party of Members of Parliament to the Fuel Research Station was paid on the day he died.

NOTES.

INDUSTRIAL FATIGUE.

IN a recent issue (June 13, page 769) we set out the suggestion, made in the fourth annual report of the Industrial Fatigue Research Board, that many of the results disclosed by its investigations should now be tried in industry under the direction of a small representative committee. This suggestion is repeated in a short report, "Results of Investigation in certain Industries" (H.M. Stationery Office, 6*d.* net), which purports to give a complete summary of the recommendations relating to specific industries that the Board has published, and commends them to the consideration of the industries concerned, in the hope that they will find means for testing many of them in practice. The Board's recommendation will doubtless be considered by these industries, and a prudent decision reached. It may be doubted, however, whether for most of the investigations the Board's suggestion is not premature. Industries cannot afford repeated experiment on their methods of manufacture, and in a subject so important as the economy of energy, or the efficiency with which it is used, more than the present evidence seems to be wanted that the best means have been recommended. Apart from reports of which the methods are open to such criticism as we have offered from time to time, most of the Board's investigations have suffered from two weaknesses. They have not been planned and carried out by men familiar at first hand both with the industries and with scientific method, and they have not taken due account of the results of previous workers. In particular no attempt seems to have been made to ascertain, by inquiry from men with the necessary qualifications, what has been the outcome of the methods advocated in the United States by Taylor and his followers. It would be interesting to know what has become of these methods and their results; what works have continued to practise them; and whether the original standard of performance has been maintained, improved, or lost. Up till now the Board's work seems to have been

done without reference to previous experiments. It is easy to imagine that with restricted resources, and a membership and staff without the practical experience that is necessary for forming a judgment of any practical value, the Board has preferred to get on with such work as it could regarding the results of its investigators as pioneer discoveries. Such an attitude is the more intelligible because of the generally unsatisfactory form in which the American results have been presented. Now, however, that the Board contemplates inducing the industries to enter on practical trials it is time that the results of previous experiments with a similar object should be brought to light.

Anti-Aircraft Devices.

War would be a much less uncertain adventure if one could be assured that the party of the second part would not do a little thinking on his own account. The Germans, for instance, had devised an impregnable system of defensive lines on the Western Front, provided always that their opponents made no alterations in their methods of attack, and the "unrestricted" submarine campaign would have achieved its end if the Admiralty had not reintroduced the convoy system. This particular counter move was, of course, an old plan revived, but the counter to the machine gun, the pill box and extraordinarily elaborated defences of the Hindenburg lines, was found in the tank, with the result that though, during the summer and autumn of 1918 our own men were largely outnumbered by the defending forces, the latter were driven from "impregnable" position to "impregnable" position, and at last forced into the open, where their destruction would have been complete had the war lasted but a few weeks longer. We have heard a great deal of late of the extraordinary offensive powers of aircraft, and glowing accounts have appeared of the sinking of battleships by aeroplane bombs in certain elaborate, and unquestionably very important experiments carried out in American waters. The aeroplanes had to find their target, which was in one case about 100 miles out at sea, and then to sink it, and succeeded in effecting this mission. In a highly interesting paper, published in the April issue of "*The Coast Artillery Journal*," Lieutenant Colonel H. C. Barnes of the United States Army, makes the comment on these tests that the targets were anchored and passive, and that the successful bombs were dropped from heights far lower than could possibly have been approached to, had the targets been firing back. He gives some particulars of the new anti-aircraft guns now being produced in the United States. Of these, four types are in course of development there. One is a gun having a calibre of ½ in. Its horizontal range is 27,000 ft., and its vertical range between 9,000 and 12,000 ft. Its rate of fire is 500 rounds per minute. Fire control is maintained by means of "tracer" ammunition visible by night up to 7,500 ft., and by day up to 6,000 ft. The second gun is a machine gun with a calibre of 37 mm. firing high explosive shells which have fuzes so delicately adjusted that though quite safe to handle before firing, contact with balloon fabric is sufficient to explode them once they have left the gun. The rate of fire with this weapon is 100 to 120 shots a minute. The "straight up" range is about 14,000 ft. and "tracer" ammunition is provided which is visible up to 10,000 ft. Another anti-aircraft gun is a 3 in. weapon on a mobile mount. This is effective up to an altitude of 21,000 ft., and has a rate of fire of 15 shots per minute. The fourth gun of the series is of 4·7 in. calibre. It fires a 45 lb. shell and is effective up to an altitude of 30,000 ft. It also is to be mounted on a mobile carriage. As a supplement to these weapons schemes of indirect aiming are being worked out, which will give greater accuracy, whilst employing a smaller personnel than hitherto. Col. Barnes contends that such weapons will make it very difficult for an aircraft to hit with their bombs any mark as small as a battle ship.

The Institution of Engineers, Australia.—The quarterly bulletin of this Institution for April, the second issue, gives information on the Institution's spring conferences and on the visits of members to a number of works and places of interest in Brisbane and its environs.

SOUTH AFRICA AT THE BRITISH EMPIRE EXHIBITION.

(*Concluded from page* 174.)

Of the mining industry, with the metallurgical works that are arising in connection with it, gold mining has been till now by far the most important, representing an output of some 36,000,000*l.* a year; diamonds rank next, varying from 3,000,000*l.* to 15,000,000*l.*; and then coal, with a steadily increasing production, which in the last available figures (1921) exceeded 5,000,000*l.* The considerable number of other metals and minerals found and worked in the country are shown in a large variety of specimens. The gold mining and diamond-washing industries are represented by models, which exhibit present practice in some detail. A model is shown in particular of the lay-out of the gold recovery plant situated at the circular shaft of the New Modderfontein Gold Mining Company, Limited, at Witwatersrand in the Transvaal, from which province nearly half the world's gold production in 1919 was derived. In the Rhodesian section is another model of the workings and lay-out of the Shamva mine, in addition to one of the workings of the Globe and Phœnix mine, about five years ago. The Modderfontein mine is now down to 2,000 to 2,300 ft. below surface, but it carries about 50 per cent. more gold to the ton of rock milled than the average for the Rand, while the Shamva mine, which is practically all open cast work from a quarry on a hill, carries only about half the average of Rand mines. Each, however, worked in the manner shown in the models, is very profitable.

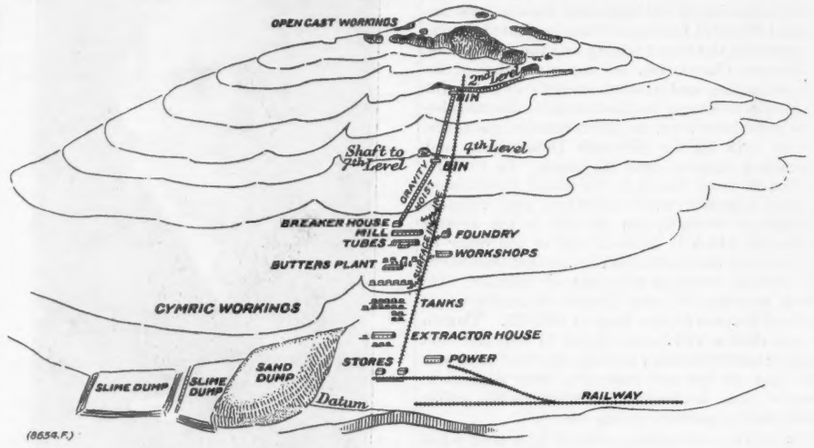


Fig. 9. Model of Shamva Mine.

In the Modderfontein mine the ore is rough crushed in the workings, and filled into 6-ton trucks which are hauled to the surface of the shaft in a cage, from which a pneumatic piston pushes them on to a graded railway leading to the storage bin, into which they are tippled, the empty truck being carried back by a creeper chain to the shaft cage level. The waste rock from the workings is similarly raised and traversed down to the sand dumps. From the bins the ore is taken on conveyor belts to the sorting and crushing station, 38 ft. above ground level. Here they are delivered into cylindrical screens, in which they are sprayed with water. The fines are thus washed out for treatment at a later stage, while the bulk of the ore is discharged on to slightly-inclined and continually moving picking belts, from which sorters pick out the barren or waste rock as the belts pass, and drop them through holes in the floor into bins, to be trammed and dumped. The sorted ore is crushed in four Gates gyratory crushers, each driven by a 60 h.p. motor, which at the same time delivers pebbles for use in the tube mills. Conveyor belts carry the broken ore to bins 45 ft. above ground level, feeding 56 Nissen stamps, each dealing with 30 tons a day, and the pulp is laundered into cone classifiers, from which the slimes pass to the slime plant and the coarse runs into tube mills—20 ft. horizontal cylinders, revolving at 28 r.p.m. with the pebbles from the crushing station. The comminuted pulp is passed over amalgamating tables—copper plates coated with mercury—at the foot of the tube mills, and there about half the gold is arrested as amalgam for recovery in a refinery. The pulp stream is then drawn into sand pumps, each lifting 1,300 tons per hour 65 ft., whence it is discharged into further cone classifiers. After the oversize has been there rejected for regrinding in the tube mills, the pulp passes through yet other cone classifiers. From these the slimes gravitate to settling tanks—Dorr thickeners—and the sands pass through a concrete conduit to a sump, whence they are pumped up to the sand plant, consisting of eight steel tanks, 52½ ft. diameter by 10½ ft. deep. The thick slime from the thickeners is mixed with sodium cyanide solution and laundered to the main pump house, whence it is lifted to agitating appliances—Brown cylindrical tanks—and the resulting slime cyanide run into a storage tank 60 ft. diameter, where it is stirred and allowed to feed a Butters vacuum filter plant. The filtrate from this contains practically all the remaining gold, and flows to the extractor house along with filtered extract of other cyanide solution which comes from the sand tanks. The barren slimes pass through a pipe line to the slimes dam, and the sands are trammed on an endless rope haulage to the sands dump. The extraction is done by means of zinc shavings in steel boxes, each 5 ft. by 39 ft., the gold being thrown down on the zinc surfaces, and the zinc is ultimately separated from the gold in furnaces, in which pure molten gold is left. Adjoining the shaft head gear a Ward Leonard winder, driven by a 5,000 h.p. motor generator set, revolves on a 24-in. shaft. The large end of its drum is 24 ft. diameter, and by its Whitmore brake control it can be stopped in 15 seconds when hoisting or lowering as fast as 4,000 ft. a minute. Air for the workings and drills is supplied by a plant of 6,500 cub. ft. per minute capacity, compressed to 112 lb. per square inch. The Rand Mines Power Supply Company delivers electricity at 20,000 volts to a transformer house, where it is transformed to 200, 500 and 115 volts for various installations. The plant described above is a little over a third of the total plant on the mine.

The processes adopted at the Shamva mine are generally similar, but vary in some details, always in the direction of a necessary economy. The result is sufficiently remarkable. With a mine 461 miles from the coast by rail, an ore going on the average just under 3·4 dwt. to the ton, and coal delivered at 39*s.* a ton, the working expenses in 1922 were just below 9*s.* a ton, including 6*d.* a ton for development and about 3¾*d.* for royalty. In part, this is due to the extreme care with which assay results are taken and recorded throughout the workings and prospecting drives. This accuracy in records is illustrated by the construction of the model itself, a sketch of which is given in Fig. 9. It is made up of a series of layers representing contours of the several levels, some 115 ft. apart.

The model is on a scale of 1 in. to 200 ft. for both vertical and horizontal distances, and on the surface of each of these layers a plan of the workings at the level in question is drawn to scale; a method that exhibits the progress of the workings with unusual clearness. Assay values, similarly, are entered on plans only for samples going as high as 0·1 dwt., but other sample points are shown by dots, thus throwing positions with appreciable values into special relief. Not only for correct connections but also for obtaining well graded levels, great care is taken in surveys, which are made mostly with the tacheometer; a marked difference is found in the tonnage hauled out of the two levels through which ore is extracted, due solely to the better grading of the lower one. The surface incline shown in Fig. 9, which is operated by electric motor, serves to convey workers and distribute stores, while ore is taken from the second and fourth levels to the mill by the gravity hoist. Among the economies effected in the working, as compared with normal practice, is the use of inclines and endless wire rope haulage for raising ore from depth instead of putting in a vertical main shaft at a greater cost both for construction and running. The introduction of the Crowe vacuum process of deærating the weak cyanide solution, used in this plant, has prevented the formation of zinc hydrate precipitate during extraction, and reduced both the consumption of zinc and the amount of gold lost to the sand dump and slime dam. The general layout of the plant is in other respects indicated by the figure. A detailed account of the working of this mine has been given by Mr. Cyril E. Parsons, its chief engineer, who has been largely responsible for its design. (Trans. of Inst. of Mining and Metallurgy, March 20, 1924.)

FIG. 10. DIAMOND WASHING PLANT.

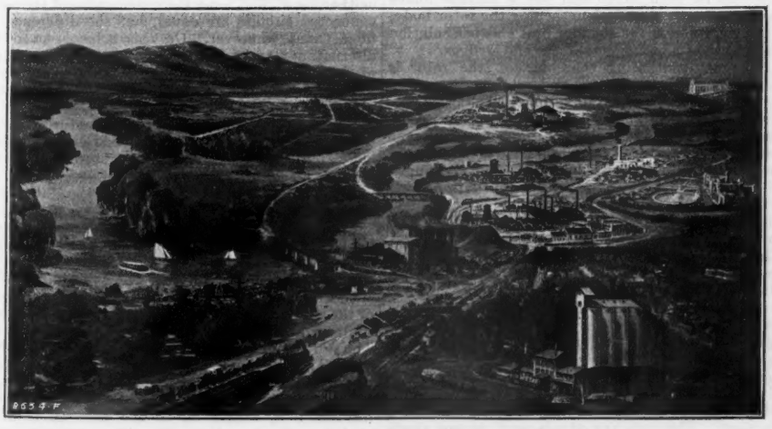


FIG. 11. THE VEREENIGING ESTATES.

The exhibit of the De Beers Consolidated Mines includes a diamond-washing plant at work (Fig. 10), erected and operated by the Diamond Producers of the Union. The process will be understood from the figure. The blue ground is suitably crushed to a size at which it can be fed to the jig, in which a concentrate including the diamonds, settles in the usual way under the pulsating action of water to which it is subjected during its travel through the jig. This concentrate is passed over on a grease table, where the grease holds the diamonds and allows other materials to be carried away. Specimens are shown of various types, both of a blue ground and of country rock in which it is found. In an adjoining stand Messrs. M. L. Van Moppes and Sons have a working exhibit of cutting and polishing diamonds, with specimens of the various industrial tools in which they are used.

These include truing abrasive wheels, this being probably their most important application, die-plates for drawing fine wire, drills for optical and similar work, the larger diamond-faced crowns for rock drilling and boring, and the less generally known type of diamond form cutters, such as are used in the manufacture of fountain-pen parts, &c., for truing materials such as ebonite to a close accuracy and high finish.

An exhibit that summarises in itself a large part of the activities of the Union is that of the Vereeniging Estates, Limited, and the Associated Industries, Vereeniging, near the middle of the east half of the pavilion. It includes samples of coal and ironstone, steel in various forms, bricks and earthenware, maize and maize products, timber, fruit, grain and fodder and wool, with heads of game still running wild in the district, specimens of game birds and a considerable collection of photographs. Vereeniging is situated on the river Vaal, nearly 5,000 ft. above sea level, 40 miles away from Johannesburg.

It has large deposits of coal, clay and lime actually in work, besides large, but as yet undeveloped, deposits of hematite ore in the neighbourhood. A forest, mostly of coniferous trees, began to be planted less than 30 years ago, and its 20 year old trees 6 ft. up the trunk measure from 12 in. diameter for oak to 13 in. for pine and 18 in. for eucalyptus. Cattle, sheep, orchards and grain all have done well, and grain elevators and a flour-milling plant have been erected with modern machinery for extracting and refining maize oil. The Brick and Tile Company have 19 down draught kilns, making high-class building and paving bricks, and 18 making salt-glazed stoneware, silica, magnesite and fireclay bricks, &c., fireclay and proof ware. Pipes up to 6 in. are made to a hydraulic test of 100 lb. per square inch, and sewerage pipes are shown up to 15 in. The exhibition stand itself is worth notice for the ingenuity with which the steel sections and other metal products are worked into its design. Fig. 11 is a photograph of a model giving a general view of the estate and its principal activities.

The steel works were founded to work up enormous Government dumps of scrap, and to investigate the suitability of native ores for iron and steel making. Much remains to be done in the latter respect, though large likely deposits exist not far off. In the meantime a steadily increasing production has been developed, now amounting to some 1,500 tons per month, produced by open-hearth furnaces and a Héroult electric furnace, with three rolling mills up to 22 in. and appropriate reheating furnaces and incidental equipment. The output doubtless is not yet large; but the works were only started in 1912, and with their complete and well-considered equipment, their rapid progress, and the increasing market when trade again becomes normal, no doubt can be felt that their production will not stop where it is. The Victoria Falls and Transvaal Power Company has a station in the district, from which it supplies both the estate and the Witwatersrand Goldfields some 45 miles away.

The basic problem of the Union of South Africa appears even more strongly in the remainder of British South Africa. Its area is more than double that of the Union, its population less than a third, and of that population not one soul in 30 is of European extraction. The most actively-organised part of this immense area is Southern Rhodesia. Small as is its proportion of white population —about 1 in 25—it is much larger than that of any other part of British South Africa outside the Union and South West Africa. It only became a self-governing Colony in October last, and has therefore joined in the Exhibition at short notice. Its exhibit represents an area of 152,000 square miles, with a population of under 900,000, of whom something under 35,000 are white. Both for agriculture and for pasturage it has great natural

resources—a fertile soil, a good rainfall and cheap native labour. Its mineral resources are considerable and various. Most of the occupied territory is from 3,500 to 5,000 ft. above sea level, and though it is geographically wholly within the tropics, its climate is much more nearly temperate. Its death rate in 1922 was only just above 10 per 1,000, and white children thrive well.

The exhibits include mineral agricultural, industrial, zoological and native sections. Of these the most complete and representative are those of minerals and agriculture. Gold is, of course, the chief mineral industry. In addition to the models of the Globe and Phœnix and Shamva Mines, to which reference has been made above, numerous specimens of gold-bearing rocks are shown from these and others. Of the many other minerals proved to exist the most important as yet are asbestos and chromite, of which Rhodesia is among the prominent producers of the world, and coal. Not only of these but of other minerals the resources are quite imperfectly explored, and the development that has been made is trivial compared with what remains to be done. The industrial section includes castings and machine work from the iron and brass foundry of Mr. W. S. Craster at Salisbury. The Beira and Mashonaland and Rhodesia Railways show films illustrating the modern plant of their workshops. Like the Union, Southern Rhodesia issues a good catalogue, and other well-written publications. They are all directed to giving accurate information in support of the material purposes for which the exhibit is made: to attract capital and suitable settlers for the development of mineral and agricultural resources, to extend markets for agricultural and mineral products, and to invite the visits of tourists and sportsmen. These doubtless are among the objects of many exhibiting colonies; but in none does their attainment seem more likely to offer an extended market for the products of the British engineering trades.

HUNGARIAN PRACTICE IN HIGH SPEED TURBO-ALTERNATOR DESIGN.*

By E. Wilczek, Budapest.

The purpose of this paper is to present some methods adopted in high-speed turbo-alternator design, of which very little information has been published. The alternators in question have been built to the designs of Dr. O. T. Bláthy.

Rotor.—The two- and four-pole rotor designs have received materially different solutions, both of which were studied with the purpose of obtaining the greatest reliability in operation.

The two-pole rotor (Fig. 1)† is of the parallel slot type, the slots being milled into the barrel-formed rotor body parallel to the axis of the alternator. The inherent advantages of the parallel slot rotor are: (*a*) Very economical machining work. (*b*) The slots are cut not only in the sides but also across the ends of the poles, so that the front parts of the exciting coils are embedded in the field core throughout their whole length and secured by it against the centrifugal force. Therefore neither supporting caps nor banding wire are used. As the winding heads are secured by the rotor core itself against relative movements, no packing pieces are required. (*c*) All the coils—consisting of flat wound copper strips—may be wound very tightly on a lathe, the mica insulation between the turns being inserted at the same time. The mechanical method of winding makes it possible to work under constant pressure and to make the coils so hard that, when finished, they give a metallic ring and constitute a very substantial piece of manufacture. (*d*) The coils having no surfaces of double curvature—as is the case with the coils of the radial slot rotor—may be insulated along their whole length and also between turns with pure hard mica.

The advantages peculiar to the special type of two-pole parallel slot rotor here considered are:—(1) The flange-shafts made each of one high-grade steel forging. (2) The steel slot-wedges. (3) The self-ventilating arrangements.

1. In order to secure the maximum possible number of ampere-turns, it is necessary to arrange the winding near the central portion of the core-ends, where otherwise the shaft would project. With this design separate shafts have to be provided, bolted on to the rotor body by means of attaching discs or flanges.

At the beginning of the development of this turbo-rotor design and even many years later, the necessity of avoiding magnetic shunting of the core flux by using driving flanges of non-magnetic material between the rotor body and shafts was considered indisputable. According to this arrangement, the shafts had to be attached to these interposed discs, and the rotor was in this way built up by assembling five main parts.

Dr. Bláthy had found by 1909 a substantially different solution. He designed the driving flange and shaft of one forged steel piece with a form which kept the leakage flux within reasonable limits and securing at the same time quite a mechanically satisfactory layout. This arrangement does away with the non-magnetic material of less satisfactory and also less reliable mechnical qualities, and reduces the number of the main rotor parts from five to three, substantially increasing the reliability of this part of the alternator.

2. The side parts of the coils are held in place by wedges generally made of non-magnetic material. Researches directed towards further development in the quality of the material led in 1914 to the change from such slot wedges to those made of high-grade steel. The form of the wedges has been designed so as to obtain the greatest possible mechanical strength, combined with a very small leakage section (Fig. 2).

Fig. 1 END VIEW OF TWO-POLE ROTOR CORE

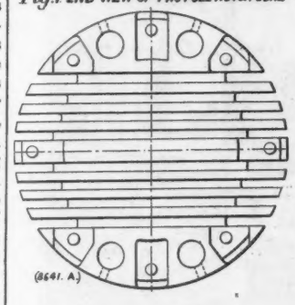


Fig. 2. STEEL WEDGE.

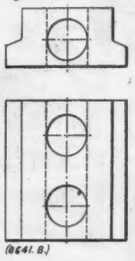


Fig. 3. TWO-POLE ROTOR ASSEMBLY.

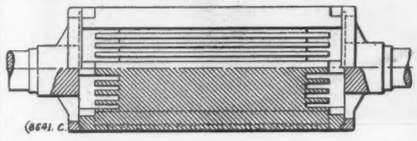


Fig. 4. FOUR-POLE ROTOR.

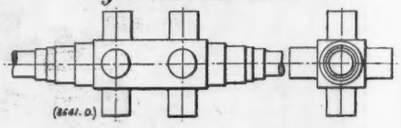
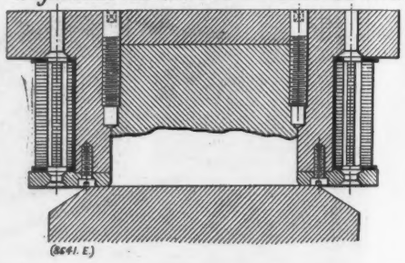


Fig. 5. FIELD POLE AND COIL OF FOUR-POLE ROTOR



The loss by both flange and wedge leakage fluxes is made up for by slightly lengthening the rotor body, which constitutes a far sounder and cheaper solution than the use of non-magnetic discs and wedges.

3. The self-ventilating character of the rotor is attained by designing flanges and rotor body so that they take care of the whole air supply (Fig. 3).

Neither built-on nor separate fans are used. Although none of these devices have caused much disturbance of service, it is certain that doing without them means an increase of reliability. The air supply, in consequence, entails an increase of ventilation work, but the gain in security by far out-weighs the slight decrease of the alternator efficiency caused by this arrangement.

The four-pole rotor design is substantially different from the two-pole type. Shaft and cylindrical pole-bodies are of one forged steel piece (Fig. 4). Steel sleeves are slipped on to the pole-bodies. The field coils are firmly secured between the pole-shoes and rings bolted on to the bottom of the sleeves (Fig. 5). The sleeves are fixed on the pole bodies by means of a large number of bolts, sunk half-way into the pole body and the sleeve. This method of securing the field coils offers the greatest safety of all designs in use at present. The coils are edge-wound, in one single layer. Their cooling is rendered more effective by a large number of ventilating holes parallel to the coil axis, bored through the whole length of each coil (Fig. 5). The air-cooled coil surface is more than doubled by this solution.

The cylindrical shape of the coils renders exact manufacturing possible. The wound coils are baked under high pressure, so that copper and insulation between turns form a compact mass on which neither heat nor centrifugal force will cause any change of form. The coils are also safe from any effect of moisture. No breakdown has ever been caused by these coils on the four-pole turbo alternators, some of which have been in operation for two decades. This type of rotor is also self-ventilating.

The rotors are made of mild steel or of nickel steel. The present limits of rated speed are:—If mild steel is used: 135 m/sec. for two-pole rotors, and 125 m/sec. for four-pole rotors. For nickel steel rotors: 150 m/sec. in the case of two-pole, and 140 m/sec. in the case of four-pole types.

Stator Winding and Bracing Arrangement.—The stator core is built up of mild steel sheets—containing about 2 per cent. silicon. Half-open slots are used. The slot insulation has always been made of hard mica even in case of low voltage turbo-alternators. Where mica insulation tubes cross the ventilation ducts they are completely protected by distance pieces so that no mica parts are exposed to high velocity air.

The possible maximum of parallel circuits per phase is even at present generally considered to be equal to the number of poles. The lowest machine voltage thus arrived at is, in case of large alternators, far from meeting the usual requirements. Consideration of the problem led to a better solution of meeting all practical conditions. The first machine with more than 2p. (number of poles) parallel circuits per phase was built in 1911. Figs. 6 and 7 show the scheme of connections for a two-pole turbo-alternator with four parallel circuits per phase. The E.M.F.'s of the parallel circuits are equal, but there is a phase angle of 16 minutes between the two pairs of resultant vectors. The parasite current flow caused in the stator-winding by this difference amounts to such a low percentage of the full load current,* that the supplementary I^2R losses entailed by it are insignificant. Windings with 6p. and 8p. parallel circuits per phase may be designed on similar lines. In these cases neither the E.M.F.'s nor the phase angles of the parallel connected circuits are equal, but the difference is of no account whatever. On this scheme, even large alternators may be designed with an adequate number of slots per pole for obtaining a good pressure wave and also for keeping the amperes per slot within reasonable limits.

The large turbo-alternators manufactured for commercial voltages have generally one or two bars per slot, each insulated by a separate hard mica tube for the full machine voltage.

The head windings at both ends of the stator consist of evolute connections.

The bars projecting from the stator slots as well as the end connections are supported by specially designed bracing arrangement, protecting the machine against the effects of short-circuits. The solution adopted is such that each kind of stress is met by a separate part of the supporting assembly. The bracing arrangement contains three devices with separate duties, viz.: (*a*) The supporting rings "A" (Fig. 8), made of insulating material, with number and distribution according to the arrangement of the end-windings, protecting the bars on their whole projecting length. (*b*) The bolts, marked B-B, tangential to the base circle of the evolute and connections (Fig. 9), securing the latter against relative movements; and finally (*c*) the axial bolts, marked C-C (Fig. 8), locking the layers of the end-winding together and securing them in their position relative to the press ring of the stator core. Each connecting evolute being supported separately, a considerable part of the end winding surface is exposed to the ventilating air, and the cooling therefore is most effective.

Ventilation.—The rotor is designed for delivering the necessary cooling air without any mounted or auxiliary fan, giving to it ventilation which is mainly axial (both inner and surface cooling), to the stator bore an axial system of ventilation, but to its core a purely radial ventilation system. This scheme has often been used on moderate-sized alternators with more or less variation in design. Its inherent advantages are: (*a*)

* Paper, abridged, contributed to Section G of the World Power Conference on July 4, 1924.

† The illustrations are diagrammatic only.

* With 15 per cent. inherent reactance about 3 per cent. of the full load current.

Least number of changes in air direction and simplicity of castings. (*b*) The air passes through the stator core ducts after taking up the heat losses of all the other parts of the machine. This is quite a natural scheme, as the stator core is the least liable to suffer by heat effects.

Fig. 6.

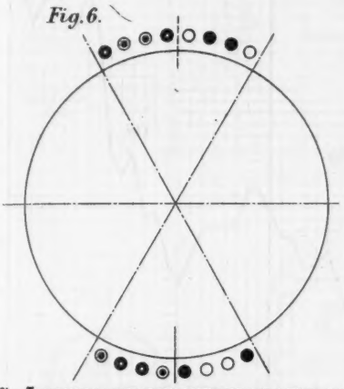
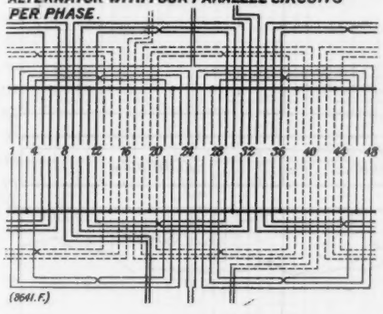


Fig. 7. SCHEME OF CONNECTIONS OF A TWO-POLE ALTERNATOR WITH FOUR PARALLEL CIRCUITS PER PHASE.



Difficulties have, with this scheme in general, arisen in the case of long machines, where air supply towards the middle of the stator core was inadequate.

The axial borings through the rotor body with their radial exit holes constitute a radical remedy to this drawback. Careful measurements of air velocity at the stator ventilation duct exits have shown that the quantity of air passing between the stator packets attains its maximum at the middle of the armature. An approximately uniform temperature of the stator core and bars is thus arrived at.

Particular care has been exercised in providing for the cooling of the head windings, these being the only parts of the alternator where the insulation consists partly of fibrous material. The bracing arrangement used is such that a great part of the surface of each evolute connection is exposed to the ventilating air, ensuring a most effective cooling to the head windings.

A comparatively small quantity of air is sufficient to keep the temperature of the different parts of the alternator within the standard limits.

Efficiency.—The self-ventilating design of the rotor increases slightly the windage of these alternators. Fig. 10 shows the efficiency curves of a 15,500 kv.-a., 6,600 v., 50 ~, 3,000 r.p.m. machine, established on the basis of all actual losses (load losses included) measured in the course of most careful tests. The difference between the efficiency and that of similar alternators, caused by the completely self-ventilating design is of no account when the improvement in safety is taken into consideration.

Failures.—No breakdown has been experienced with the four-pole rotor design described, of which forty-four—all built before 1916—are running. One rotor of this type burst in 1912 in consequence of a turbine governor failure causing the set to speed up to twice its rated number of revolutions; but an exact copy of the machine was ordered by the power supply company operating it, and has been in satisfactory service ever since 1913.

No bursting or similar breakdown has ever happened with the 160 two-pole rotors, of which the majority were built before 1918. Since 1918, five two-pole rotors, having between them sixty-four years of service, have been rewound in consequence of insulation failures.

The four-pole stator failures which have occurred since 1918 are of a slightly larger percentage than the two pole stator breakdowns given below. They have mainly been experienced on some large machines after many years of service, these having been built at a period when the skin effect was not so completely taken into consideration as in later years.

Seven stator failures have been experienced since 1918 with the 160 two-pole alternators, these representing a total of about 900 machine-years of operation for the period under consideration. The leading point in establishing the foregoing designs was the importance ascribed to safety in operation.

Fig. 8. LONGITUDINAL SECTION OF BRACING.

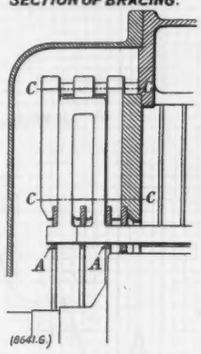


Fig. 9. END VIEW OF BRACING.

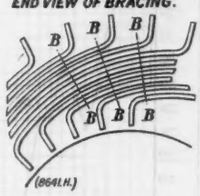
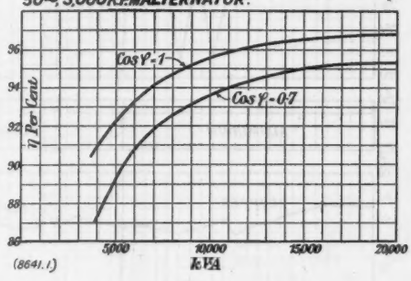


Fig. 10. EFFICIENCY CURVES OF A 15,500 kVA, 6,600 V, 50 ~, 3,000 R.P.M. ALTERNATOR.



NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—The annual general meeting of the members of the North of England Institute of Mining and Mechanical Engineers will be held in the lecture theatre of the Institute, Newcastle-upon-Tyne, at 2 o'clock, on Saturday, August 9.

THE INTERNATIONAL LIFE-BOAT CONFERENCE.—In our issue of July 4 it was stated that the Dutch lifeboat Brandaris was fitted with a semi-Diesel opposed twin-cylindered de Booy engine of 90 h.p. This is not the case; the engines fitted are two standard 45 h.p. single-cylinder Kromhaut semi-Diesel ones, manufactured by Messrs. D. Goedkoop, Jr., Limited, of Amsterdam.

STEAM TURBINE FOR CANADA.—A report has been received from H.M. Trade Commissioner's Office at Toronto to the effect that the City of Toronto Department of Works is calling for tenders for the supply and installation of one 400 h.p. steam turbine for the water supply of Toronto. Tenders close on August 19. United Kingdom firms in a position to supply British materials can obtain further particulars on application to the Department of Overseas Trade, 35, Old Queen-street, London, S.W.1, quoting reference A.X. 1150.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—The next examination of associate membership of this Institution will be held on October 30 and 31, and November 1 of this year. Candidates must be either students or graduates of the Institution or must have lodged with the secretary a duly completed form for election as associate member. Entry forms for the examination, which must be filled in and returned by September 1, can be obtained on application to the Secretary, The Institution of Electrical Engineers Savoy-place, Victoria Embankment, W.C. 2.

REDUCED TRAMWAY RECEIPTS.—According to the official returns of 34 of the principal tramway undertakings in the United Kingdom, as published in *The Tramway and Railway World*, the total receipts for the week ended July 5 last were 346,222*l.*, or 8,251*l.* less than for the corresponding week of last year. The total length of single-line track covered by the returns was 1,948 miles, so that the current receipts per mile work out at 177*l.* 14*s.* 8*d.*, as compared with 181*l.* 19*s.* 4*d.*, which was the corresponding figure for a year ago. The reduction in the receipts thus amounts to 4*l.* 4*s.* 8*d.* per mile for the week in question, or about 2¼ per cent.

ELECTRICAL RECORDING INSTRUMENTS AT THE BRITISH EMPIRE EXHIBITION.

ONE of the factors that has contributed to the rapid development of electrical engineering is the comparative ease with which accurate measurements of the quantities involved can be obtained. For the same reason it probably follows that measuring instruments are employed in electrical work to a greater extent than is the case in any other branch of engineering. The manufacture of the necessary apparatus has now become a very extensive business, which is usually carried on either by specialist firms or by separate departments of the larger electrical manufacturing organisations. Both classes of instrument makers are well represented in the electrical section of the Palace of Engineering at the British Empire Exhibition, and it is with some of the products of one of the specialist firms, viz., Messrs. Everett, Edgcumbe and Co., Limited, Collindale Works, Hendon, N.W.9., that we now propose to deal.

For many purposes a knowledge of the value of the voltage, current, or other electrical quantity at any particular time, such as is supplied by an indicating instrument, satisfies all requirements, and the greater part of the instruments in common use are of this type. There is now, however, an increasing demand for instruments giving a continuous record of quantities over a long period, such records then being available for reference at any time, and supplying useful information as to the fluctuations which have occurred at times when the instrument was not under observation. The records can also be used, of course, for determining the mean value of the quantity recorded over any given period.

Continuous records are now frequently employed by power-station engineers for the purpose of checking the consumer's power factor, in order to find some method of improving it. Figs. 1 and 2, on page 200, illustrate a recording power-factor meter of the switchboard type, made by Messrs. Everett, Edgcumbe for this class of work, and included in their exhibit at Wembley. The principle upon which these instruments operate is now well known, but attention may be called to the recording mechanism of which a large-scale photograph is reproduced in Fig. 2. The marking arrangement commonly employed in recording instruments, consists of a pen and small ink reservoir attached to the end of the pointer. This arrangement gives satisfactory results when the load is steady, but when the pointer is subjected to large and continuous fluctuations the ink supply is rapidly exhausted, while if a larger reservoir is fitted, errors are introduced owing to inertia. These disadvantages are overcome in the instrument illustrated by keeping a comparatively large supply of ink in a stationary well, into which dips one end of the pen arm. The latter is in the form of a fine tube, and the ink drawn up by capillary action flows along the tube to the other end, which is fitted with a small nozzle and rests lightly on the paper. The tubular pen arm is fixed to a horizontal bar, the ends of which are formed with knife edges and rest in grooves on the upper ends of two uprights, clearly visible in Fig. 2. These uprights are carried by the moving system of the instrument, so that their movement is imparted to the pen arm. Two adjustable balance weights, also shown in the illustration, are provided to enable the pressure of the pen on the paper to be varied at will. The capacity of the ink well, we understand, is sufficient to enable a complete record to be obtained on a roll 65 ft. in length with one filling, even with extremely fluctuating loads. It should also be mentioned that since the opening through which the pen tube passes into the ink well is only just large enough to give sufficient clearance for rotation, evaporation of the ink is practically prevented.

A similar instrument, in portable form, so that it can be taken from place to place and, if necessary, temporarily installed in the consumer's premises, is illustrated in Fig. 3, which shows the instrument with the back cover removed to expose the mechanism. The latter, it will be noticed, is easily accessible. For averaging up the records obtained from power-factor meters and other recording instruments, Messrs. Everett, Edgcumbe have put upon the market the special form of planimeter illustrated in Fig. 4. The mean height of the record, and consequently the average value of the quantity recorded, could, of course, be obtained by an ordinary planimeter by measuring the area and dividing by the length of the base line. The whole area would, however, have to be circumscribed by the tracer point of the planimeter, an operation which would be impracticable in the case of a record 65 ft. in length. In the instrument illustrated, it is unnecessary to return to the starting point along the base line, since the recording wheel is so arranged that its plane is at right angles to the base line when the tracing point is on the line. The area is thus obtained by starting from the base line and moving the tracer arm along one of the curved ordinates until the curve is reached, tracing out the curve by moving

the paper along as required, and then returning to the base line along the last curved ordinate. The reading of the wheel is then a measure of the area under the curve, and the mean height can be obtained by dividing the area by the length of the record as indicated by the number of divisions of the base line passed over. It will be obvious that the result obtained will be precisely the same as would have been the case if the tracer point had been actually returned to the starting point, since no rotation of the wheel would occur while it was being drawn along the base line.

Accurate continuous measurements of speed, current voltage, power, and other quantities are particularly useful in investigating the working of electric railways, tram cars, and battery vehicles, but special precautions must obviously be taken in the design of recording instruments for this class of work owing to the vibration to which they are subjected in use. Messrs. Everett, Edgcumbe have designed a complete series of recording instruments to comply with the conditions existing in traction work, and we illustrate one of these instruments, as an example, in Fig. 5. The instrument illustrated, it will be noticed, is arranged to give three simultaneous records on separate charts, but similar instruments are supplied to give any number of records up to five. The mechanism, as shown, is enclosed in a box suspended on springs inside a skeleton framework of wood, this form of suspension serving to minimise the effects of vibration. The most important feature of the apparatus, however, is the method adopted for driving the paper and pen gear. For this purpose, a small constant-speed motor is employed, the motor driving all the charts in complete synchronism. A paper speed of 3 in. per minute is usually employed for railway work, but, by means of change wheels, speeds of 1 in. and 6 in. per minute can be obtained at will. Moreover, the speed of any one of the charts can be changed independently of the others, a feature which is often of considerable utility.

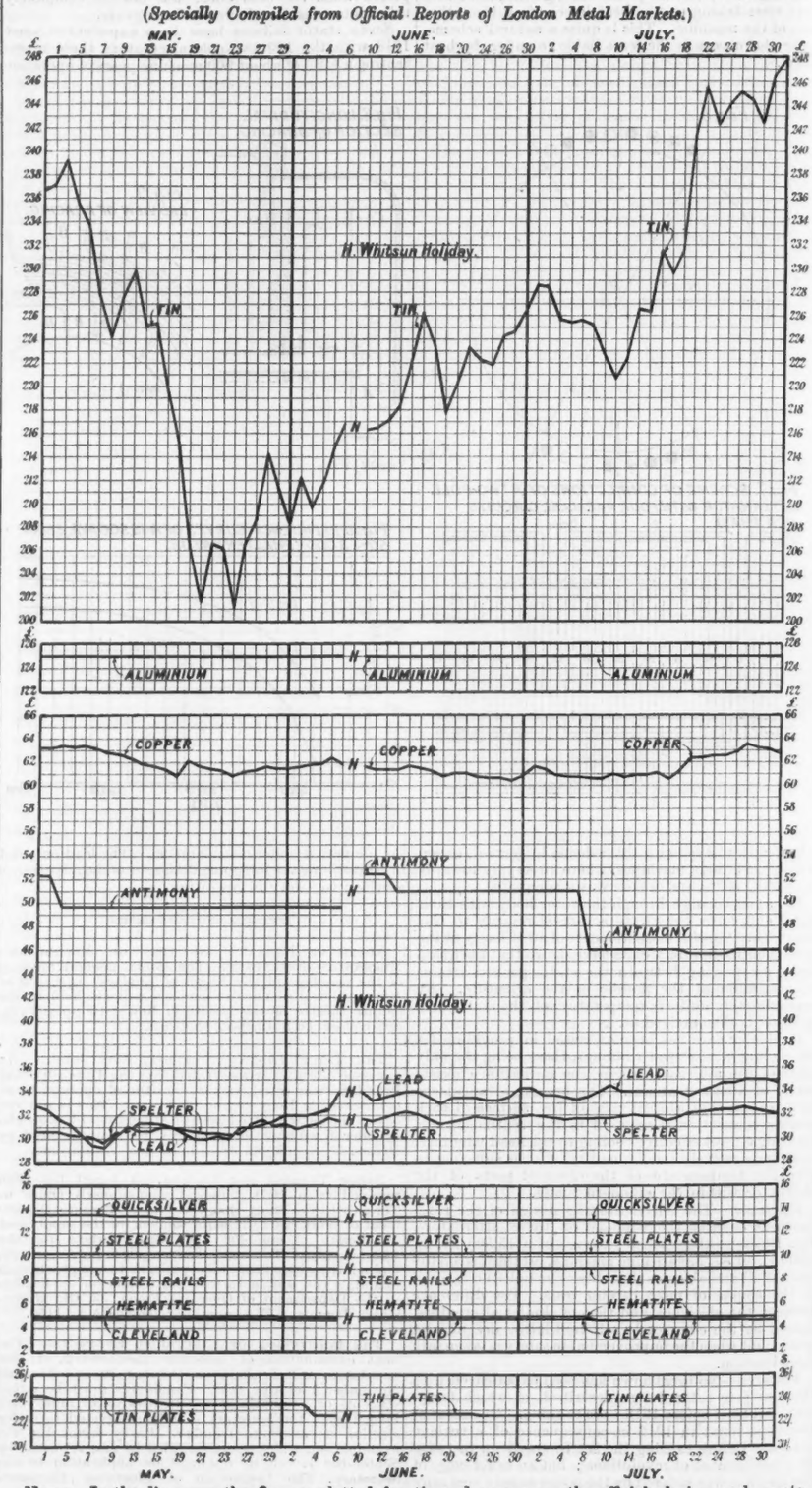
The recording pens are not operated directly by the moving system of the instruments, but by screw mechanism driven by the small motor above referred to and controlled by relays. When the pointer of one of the instruments moves in one direction, it makes a contact permitting a current to flow through a small electromagnet, which brings the edge of a friction disc into contact with a disc mounted on a shaft driven by the motor. The friction disc is connected through gearing to a screw on which the pen is mounted, and the rotation of the screw moves the pen along in the same direction as the motion of the instrument pointer. The contact is moved simultaneously with the pen, and as soon as it is separated from the pointer the motion of the pen ceases. If the pointer moves in the opposite direction, another electro-magnet is energised, drawing the opposite edge of the friction disc into contact with a disc on the motor-driven shaft, and by this means the pen is also moved in the opposite direction. It will be understood that, with this arrangement, the moving system of the instrument is relieved of the work of moving the pen, the power for which operation is supplied from the small motor. A large ink reservoir can thus be mounted on the pen without affecting the accuracy of the record; the latter, it should be mentioned, has rectilinear co-ordinates. The makers claim that the pen responds instantly to any changes in the quantities being measured, and that the movement is free from any tendency to hunting or swinging. They also state that the records are quite unaffected by the vibration and shocks to which the instruments are subjected in use.

To obtain a speed record with the instruments described above, the transmitter illustrated in Fig. 6 is employed, although it can also be used in connection with indicators and recorders in many other applications. It consists of a specially-designed magneto generator, enclosed in a water-tight case and driven by roller chain, or other means, from the axle of the vehicle. The electro-motive force of the generator is directly proportional to the speed of rotation of the armature, so that by connecting it electrically to a suitably graduated voltmeter, a direct indication, or a record, of the speed can be obtained. Any speed, high or low, can be measured by employing a suitable gear ratio between the axle, or other rotating shaft, and the generator.

The firm's exhibit includes a number of protective relays, which are shown in actual operation; examples of their "Superscale" ammeters, voltmeters and wattmeters which have exceptionally long and open scales; a convenient portable testing set for alternating-current work; extra high-tension electrostatic voltmeters, which have been standardised up to 300,000 volts; and radio-frequency ammeters for measuring currents up to 500 amperes at frequencies up to 1,000,000 cycles per second or over. Another of Messrs. Everett, Edgcumbe's exhibits, viz., their "Cube" photometer for determining the mean sperical candle power of electric lamps, has already been illustrated and described on page 543 of our last volume.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

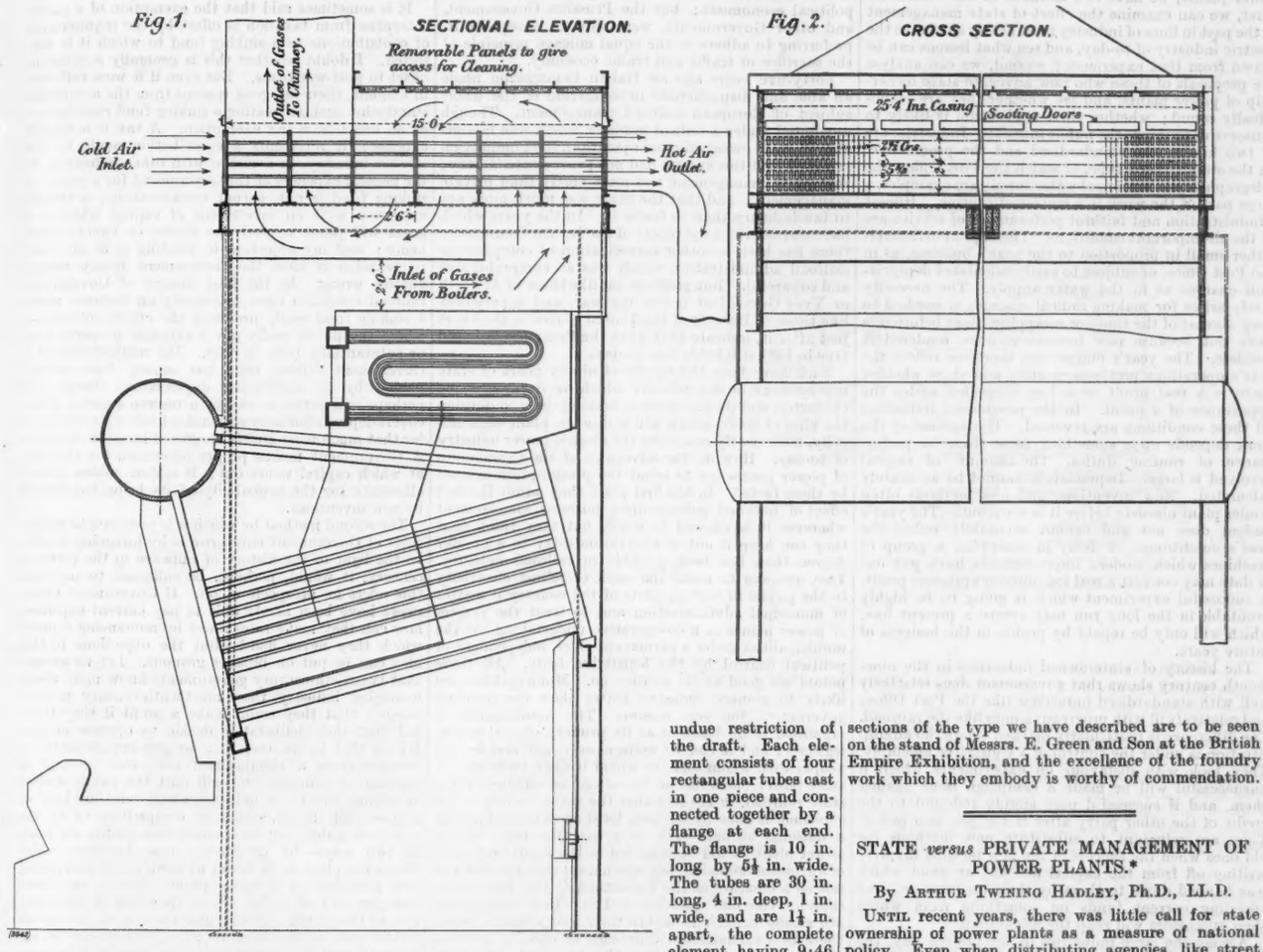
(Specially Compiled from Official Reports of London Metal Markets.)



NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given, in the case of steel plates are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of quicksilver is per bottle, the contents of which vary from 70 lbs. to 80 lbs. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

RECTANGULAR TUBE AIR HEATER APPLIED TO WATERTUBE BOILER.

CONSTRUCTED BY MESSRS. E. GREEN AND SONS, LIMITED, ENGINEERS, WAKEFIELD.



RECTANGULAR TUBE AIR PRE-HEATER.

THE considerably increased efficiency of a boiler plant when the air for combustion is heated before it enters the furnaces has been amply demonstrated, and consequently a good deal of attention is being paid to the design of air-preheating apparatus. The advantages due to the use of such apparatus are greater than the mere recovery of the heat, which would otherwise go to waste. Hot air is more active than cold air in promoting combustion, with the consequence that low-grade fuels can be burnt more readily, and it appears likely that with heated air the arches usually found necessary with chain grate stokers can be much shortened, even if not altogether dispensed with. Any step in this direction is highly beneficial, for not only are arch troubles minimised or eliminated, but the screening of the heating surface of the boiler from the radiant heat of the burning fuel, which any arch construction causes is also very much reduced. For these and other reasons modern power station practice is tending more and more to the use of air preheating, especially as the higher steam pressures now being employed, and the policy of inter-stage feed water heating, are diminishing the field for economisers, thus indicating the necessity for some other method of utilising the heat of the flue gases.

Messrs. E. Green and Son, Limited, of Wakefield, whose name is so well known in connection with economisers, have now developed an air-heater which can be used either in conjunction with, or in substitution for, economisers. The general practice in connection with air heaters is to employ either steel tubes or thin plates of sheet metal as the heat transmitting surfaces, but Messrs. E. Green and Son, no doubt guided by their economiser experience, have adopted cast iron throughout in their design. The Green air pre-heater is built up of a number of elements grouped together in series and in parallel in such a manner as to provide the heating surface required in any case without an undue restriction of the draft. Each element consists of four rectangular tubes cast in one piece and connected together by a flange at each end. The flange is 10 in. long by 5½ in. wide. The tubes are 30 in. long, 4 in. deep, 1 in. wide, and are 1¼ in. apart, the complete element having 9·46 sq. ft. external heating surface and 8·33 sq. ft. internal heating surface. The flanged faces of the elements are finished by machining or grinding and are held together by bolts.

The final flanges on the air inlet and outlet sides are bolted to an airtight sectional framework with a converging mouthpiece opposite each tube, in order to prevent undue eddying of the air. Each element weighs about 80 lb., and though naturally heavier than a sheet metal construction of the same heating surface, the use of cast iron is expected to give a considerably longer life under the conditions in which air heaters have to work. Each element occupies a space of 1 cub. ft., and a series of elements which, with their casing, need not occupy a greater height than 3 ft. or 4 ft., can be arranged to supply the requisite quantity of heated air to the grate of a watertube boiler, as shown in Figs. 1 and 2 above. It will be seen that the whole surface of the boiler setting is covered by the elements, the result being a shallow arrangement, all parts of which are readily accessible for cleaning or inspection. The flue gases sweep the flat surfaces of the tubes transversely, passing through the heater in streams 1⅛ in. thick and 29 in. wide. The air passes longitudinally through the inside of the tubes, in streams 4 in. by 1 in., in cross section. The contra-flow principle has been adopted, the air passing from the cooler to the hotter portion of the heater on its way to the furnace.

Messrs. E. Green and Son, Limited, have carried out a number of very careful experiments to determine the rate of heat transmission through heating elements of the type in question. These show that the number of British thermal units transmitted per hour per degree difference in temperature between the gases and the air, varies from 1·8 for an air velocity of 1,000 ft. per minute to 3·3 for an air velocity of 2,500 ft. per minute. These rates are said to be practically the same as, if not higher than, the rates obtained with sheet iron heaters now on the market. Air-heater sections of the type we have described are to be seen on the stand of Messrs. E. Green and Son at the British Empire Exhibition, and the excellence of the foundry work which they embody is worthy of commendation.

STATE *versus* PRIVATE MANAGEMENT OF POWER PLANTS.*

By ARTHUR TWINING HADLEY, Ph.D., LL.D.

UNTIL recent years, there was little call for state ownership of power plants as a measure of national policy. Even when distributing agencies, like street railways or electric lighting plants, were managed by municipalities, they frequently preferred to buy their power from some private company instead of producing it themselves. But in the present century two causes have combined to foster a sentiment in favour of making electric power production a government enterprise. In the first place, the increased use of water, as a source of power, in itself fostered such a demand. Private companies which used water appeared to many people to be getting their power at public expense, because the government had given them control of a natural monopoly. The general public did not understand how much capital and intelligence were needed to make water power available for use. And in the second place, it has gradually become evident that the different power plants of the country could no longer be regarded as wholly separate operating units. They must work together as an organised nation-wide system if they are to deliver and sell their product to the best advantage. Any government is always inclined to be jealous of a nation-wide organisation which it does not itself make and control.

Under such circumstances the question of public *versus* private management tends to become one of sentiment rather than of business. Even if you can show a large number of instances where state managements costs more than private management, or has involved higher rates, or has been given up by communities which have tried it, you do not make much impression on the advocates of government ownership. "The new democracy is passionately benevolent and passionately fond of power." Many voters are prepared to pay whatever price may be necessary to protect them against the dangers which they apprehend from predatory wealth. Every new form of industrial combination is likely to be made an occasion for extending state ownership unless overwhelmingly strong

* Paper, abridged, contributed to the World Power Conference, July 3, 1924.

general reasons can be urged against such a policy from the public standpoint.

To judge of the probable effect of state ownership of power plants, we have two methods at our command. First, we can examine the effect of state management in the past in lines of industry most nearly similar to the electric industry of to-day, and see what lessons can be drawn from that experience; second, we can analyse the proposals of those who now advocate state ownership of power plants, and see whether they are economically sound; whether their application is likely to conserve or to injure the public interests. Industries are of two kinds; the standardised and the progressive. In the standardised type, of which the Post Office, the telegraph or the municipal water supply are examples, a large part of the work is a matter of routine. Honest administration and faithful performance of service are of the all-important conditions. The capital invested is either small in proportion to the year's business, as in the Post Office, or subject to easily calculated depreciation charges as in the water supply. The necessity rarely arises for making radical changes of method to keep abreast of the times or scrapping plant before it is worn out because new inventions have rendered it obsolete. The year's budget can therefore reflect the year's operations pretty accurately and show whether there is a real profit or a loss concealed under the appearance of a profit. In the progressive industries all these conditions are reversed. The success of the work depends upon something more than the performance of routine duties. The amount of capital involved is large. Depreciation cannot be accurately calculated. New inventions and new methods often render plant obsolete before it is worn out. The year's budget does not and cannot accurately reflect the year's conditions. A delay in scrapping a group of machines which modern improvements have put out of date may convert a real loss into an apparent profit. A successful experiment which is going to be highly profitable in the long run may create a present loss, which will only be repaid by profits in the budgets of future years.

The history of state-owned industries in the nineteenth century shows that government does relatively well with standardised industries like the Post Office, and relatively ill with progressive ones like the railroad. The difference is particularly marked where the administration is under the control of a legislative assembly. They look with disfavour on experiments which if unsuccessful will be made a campaign issue against them, and if successful may simply redound to the credit of the other party after it has got into power. They are reluctant to substitute new methods for old ones when the success of the new method involves writing off from the capital account an asset which was handed down to them by their predecessors, and spending current funds on something from which their successors will reap the advantage.

Among the large industries of the present day, the one which is least standardised and most progressive in its character is the electric power industry. Among those of the nineteenth century, the one which was least standardised and most progressive was the railroad industry. Amid all their external differences, the things which affect the relations of these two industries to the government are singularly alike. The history of state railroad management in the last century should therefore indicate with a good deal of accuracy what results we may expect to reach, and what dangers we have to fear if electric power development should be placed in government hands.

In the first place, state railroads have habitually proved unprofitable. Though every great country with the exception of Great Britain has made experiments in state railroad operations, only two—Prussia and the South African Dominion—have succeeded in earning the full amount of interest on the capital invested. The hopes of lightening the burden for future generations by sinking funds, which were frequently cherished at the outset, have not been realised. In the second place, no operating improvement of importance has ever had its origin on a government railroad system. Telegraphic train orders, interlocking switches and signals, air brakes, automatic couplers, all had their origin on the private railroads of England or America. Government railroads gradually introduced them after they had been tried out on private lines, but they did not originate them. Improvements in equipment and traction, by which traffic could be carried at low unit cost, have almost always been due to private initiative. This absence of initiative in method is peculiarly striking in the case of Prussia because it was manifested at a time when every form of private business in that country was getting ahead of the rest of the world instead of falling behind it. In the third place, the state roads were equally backward in commercial improvement. The thing that made it practicable to reduce railroad rates so rapidly during the latter half of the nineteenth century was the development of a system of tariffs which made a large traffic in cheap goods possible, which encouraged long-distance shipments, and which utilised the invested capital to the fullest extent. The advantages of this system for the public as well as the railroads were fully recognised by German political economists; but the Prussian Government, and other Governments, were slow in accepting it, preferring to adhere to the equal mileage principle at the sacrifice of traffic and traffic economy.

Forty-five years ago an Italian Commission made an able and dispassionate investigation of the whole subject of European railroad management. Though appointed under a radical minister which was favourable to state ownership and operation, the Commission reported that this system had not proved satisfactory; that state management was more costly than private management; and that the State was much more apt to tax industry than to foster it. In the years which have elapsed since the report of the Italian Commission there has been no other investigation of comparative railroad administration which was so comprehensive and so careful. But publications like those of Acworth or Yves Guyot just before the war, and experiences like those of Italy or of the United States in the years just after it, indicate that what the Commission found true in 1881 still holds true to-day.

Such have been the results of ninety years of state management in the industry which, in its progressive character, and its problems of making rates to develop the kind of traffic which will utilise the plant economically, most nearly resembles the electric power industry of to-day. How do the advocates of state ownership of power plants try to rebut the presumption created by these facts? In the first place they admit the bad effect of national politics upon business management wherever it is allowed to enter, but they think that they can keep it out of electric industry to a greater degree than has been possible in railroad industry. They propose to make the work of selling electricity to the public in various parts of the country a matter of municipal administration and to treat the system of power plants as a co-operative undertaking for the municipalities under a permanent chief, independent of political control by the legislative body. All these points are good as far as they go. Municipalities are likely to manage industry better than the national government for two reasons. The municipality is organised to do business as its primary object, not to legislate; and it can be more closely watched by the people with whom and for whom it does business. A state power plant has an important advantage over a state railroad, in the fact that the actual selling to the consumer is done by separate local agencies and not by a national agency. The idea that the chief of the power plant should be regarded as the agent or trustee of a group of municipalities which want cheap power, and not as a creature of the legislature, is also thoroughly sound. The one question is this: How many men are strong enough to assert their independence when there is a fundamental difference of opinion between them and the legislative assembly as to what ought to be done? The nineteenth century has given us instances of a few such men, but there have not been anywhere near so many as we needed. Is the twentieth century better off in this respect?

I am content to leave this as a query, and pass on to a more important part of our subject. Assuming the administration to be thus organised and the chief to have this power and this permanence, what policy do they propose to pursue? What advantage will their system offer the community if successful? The answer generally is that they propose to give lower rates to the consumer either now or in the futuro than private companies can afford to give. They claim that they are able to do this by their exemption from taxation and by the fact that they are not trying to make a profit as private companies do, but are content to pay interest and perhaps contribute to a sinking fund.

The proposal to exempt a large group of industrial investments from taxation is always open to grave criticism. The cost of electric light or electric power is not done away with by such exemptions. It is merely shifted to other shoulders than those of the producer of electricity. The taxes for the support of the government in general have to be paid by somebody. After making all due allowance for the things which a state-owned power plant might do to reduce the budget of municipalities which it serves, the fact remains that the exemption of all new capital engaged in electric production from its share of the burden of taxation must mean heavier burdens on everybody else—higher rates of taxation for the land owner, higher rates of interest for the borrower, and too often higher surtax rates for the man of initiative and energy. In his recent book on taxation, the United States Secretary of the Treasury has shown how dangerous is this added burden under present conditions and how severe is the resulting loss to the country. This kind of exemption also has a bad effect on the morale and efficiency of a government industry. If the manager of a private company has to pay interest and taxes in order to show a balance on the right side and the managers of a government property can do so by paying interest alone, the latter tends to over-estimate the excellence of the work he is doing and content himself with a lower standard of efficiency and economy.

It is sometimes said that the exemption of a public enterprise from taxation is offset by the requirements of contributions to a sinking fund to which it is subjected. I doubt whether this is generally a sufficient offset to post-war taxes. But even if it were sufficient in amount, there are good reasons from the accounting standpoint against treating a sinking fund contribution as an offset to a tax exemption. A tax is a current expense; it represents a contribution made by the electric industry, in common with other industries, to the general expenses of the Government for a year. A sinking fund is not, except constructively, a current expense; it is an investment of capital which you guess will prove a good one fifteen or twenty years hence; and my objection to treating it as an offset to taxation is that the Government nearly always guesses wrong. In the long history of Government railroad operation there is scarcely an instance where a sinking fund really produced the effects intended—where the public really got a valuable property free, or substantially free, of debt. The maintenance of a Government sinking fund has usually been accompanied by an inadequate depreciation charge; or perhaps it is better to say by a reserve account which covers depreciation only and makes little or no allowance for that much more fruitful source of loss, obsolescence. A Government makes proper allowance for the rate at which capital wears out; it seldom makes proper allowance for the probability of its being superseded by new inventions.

The second method by which it is proposed to reduce costs of Government enterprise is by foregoing profits. In the light of the history of railways in the previous century, it would, perhaps, be sufficient to say that this offers no prospects at all. If Government enterprises have been barely able to pay current expenses, how can they make rates lower by renouncing a profit which they never had? But the objections to this idea can be put on broader grounds. Let us assume that twentieth-century governments know more about managing industry than nineteenth-century governments; that they could make a profit if they tried, but that they deliberately decide to operate at cost. I hold that in the case of a progressive industry, as distinct from a standardised one, this attempt is unsound in principle and will hurt the public instead of helping it. In an industry where rates are kept at a reasonable figure, either by competition or by the action of public service commissions, profits are made in two ways—by developing new business which allows the plant to be better utilised, or by introducing new machines or methods which cheapen the direct cost per unit of traffic. In neither case is there any loss to the public: in the first there is an immediate public gain in the form of a larger service; in the second there is a possibility of public gain which becomes an actuality as soon as the use of the new method becomes general. For the experience of every industry with large fixed capital shows that a reduction of unit costs makes a reduction of rates not only possible, but profitable. This is the way progress is made. This is the way in which new ideas are introduced and developed which mean big gains for the public. If we can get a real improvement of machinery or of method, the price paid in the form of profit is always small in comparison with the general gain to the community.

In his remarkable work on "The State in its Relation to Trade," Lord Farrer, for many years Permanent Secretary of the British Board of Trade, has shown the folly of attempting to reduce rates by limiting profits. The laws controlling the gas companies of England, which were based on this idea, had the opposite effect to that which was intended: they prevented reduction because they took away the motive for reduction. If dividends were limited to a fixed amount, there was no longer any stimulus for introducing new methods which would lower costs and increase sales. Now this disability, which was imposed upon the gasworks of England in the nineteenth century, and which people are trying to impose upon the railroads of America in the twentieth (to the great public detriment in either case), represents a chronic condition in government-owned industries which claim to operate at cost. Those in charge are given neither the motive nor the means to handle progressive industry by the most progressive methods on either the operating or the commercial side.

The question whether a new method will work commercially is always a doubtful one. There are more failures than successes. The immediate financial effect of trying a number of experiments simultaneously will appear to the auditors of the year's accounts to be bad. Not until you know which of them is going to work will you be able to show good results; often not until several years later. The more revolutionary the success of the experiment in reducing cost to the

THREE-THROW HORIZONTAL SEWAGE PUMP.

CONSTRUCTED BY MESSRS. HOLLINGS AND GUEST, LIMITED, ENGINEERS, BIRMINGHAM.

Fig. 1.

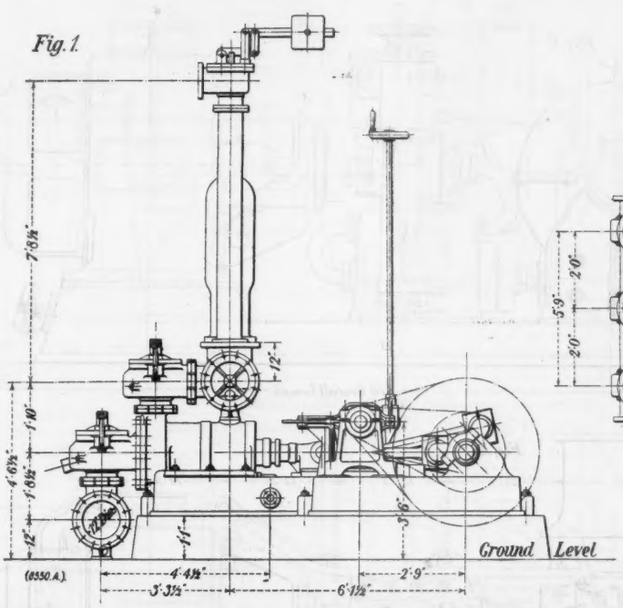
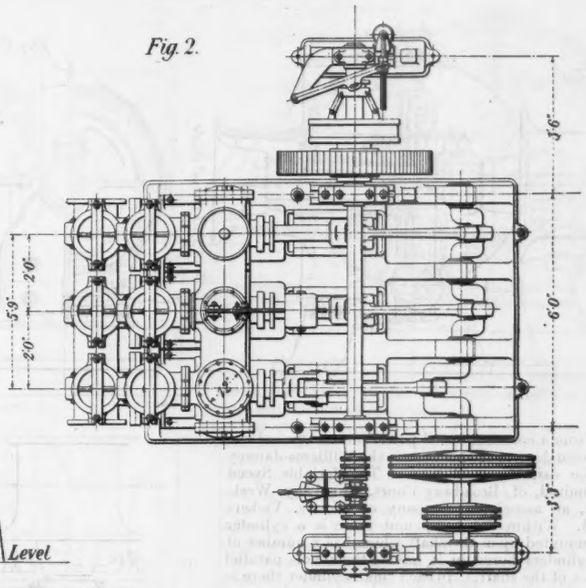


Fig. 2.



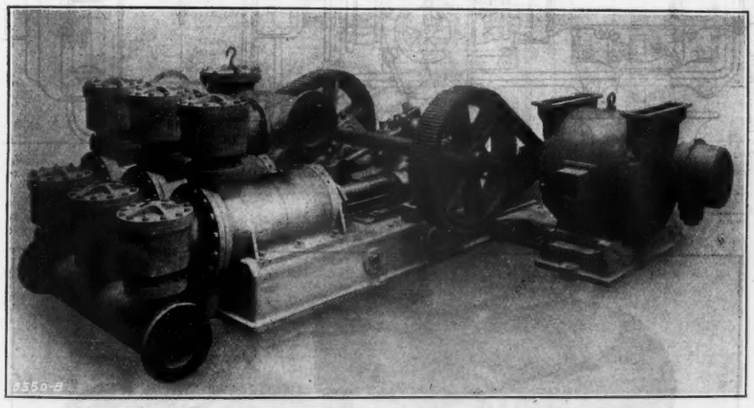


FIG. 3.

HORIZONTAL SEWAGE PUMP.

WE illustrate in Figs. 1, 2 and 3 on the present page, a large horizontal sludge pump, built by Messrs. Hollings and Guest, Birmingham, for the Birmingham Drainage Board. The pump is of the three-throw horizontal single-acting type, having three pistons 15·5 in. in diameter, with an 18-in. stroke, capable of delivering 1,000 gallons of sludge per minute to a sewage farm situated at a distance of five miles. The pump is motor-driven through chain-gearing, arranged to give two speeds of 15 and 30 r.p.m., when delivering and circulating respectively.

The normal duty, when delivering, is 500 gallons per minute, against a total pressure head of 50 lb. per square inch, plus 10 lb. per square inch suction lift; when circulating, the pump works against a total pressure head of 25 lb. per square inch, plus 10 lb. per square inch suction lift. The maximum starting pressure, due to the viscosity of the sludge or temporary blockage of the mains, has been taken at 100 lb. per square inch, plus 14 lb. per square inch suction lift. The first reduction from the motor to the intermediate shaft is by an inverted tooth chain, and the second reduction from the intermediate to the crankshaft, is by triplex roller chain; the use of these chains results in very quiet running.

The crankshaft and the intermediate shaft are of steel, running in gun-metal bearings; the connecting rods have gun-metal bearings at each end. Special attention has been given to the valves; these are of gun-metal, and are designed to give an entirely clear way for the sewage. The opening through the valves is 8 in. in diameter; the suction and delivery pipes are 12 in. in diameter. The pump plungers although single-acting, are of the piston type, the rods passing through a gland in the usual way. The inside ends of the barrels are vented, and are provided with a drain to carry away any sludge that may leak past the piston packing, making it practically impossible for any trouble to arise through leakage into the pump house.

The electric motor which drives the pump is a 60 brake horse-power machine, of the pipe-ventilated type, fitted with slip-rings, taking three-phase, 50-cycle current at a pressure of 415 volts.

The whole is mounted as a cast-iron base, machined to receive the pump bodies, guides and crankshaft bearings. The castings are exceptionally heavy for their work; ample bearing surfaces are provided and all parts are easy of access for maintenance and repairs.

VARIABLE-SPEED WINCHES.

THE combination of a pump, so arranged that it will give a variable delivery when run at a constant speed, with a reversed pump, used as a motor unit, has proved an economical and efficient means of obtaining variable

public, the more old plant you have to scrap because you cannot use it under new rates and new conditions. If the producing plants are owned by private capital, individuals or groups of individuals have the chance to try these experiments at their own risk. The gambling instinct is sufficiently strong in human nature for each man to be ready to back his own guess as to what he can do with all the money that he can himself afford, or get his friends to supply him with. Most of this is lost. The profit on the invention that succeeds or on the method that proves useful seldom equals the aggregate loss on the inventions or methods which look good in theory but prove bad in practice, but the companies gain, and the communities gain, largely in the long run from finding out which invention is successful and utilising it. It is very difficult, if not actually impossible, for a state-managed industry to be free to try this sort of experiment. It is not because the chief insists on pecuniary rewards for himself. If he is a man of the right sort the ambition to do public service will be even stronger than the ambition to make money. But he cannot try all the experiments at once on the public account; and in the light of the way governments have treated inventors, he finds it very hard to get other people to try the experiments at their own risk. He has to confine himself to a very few experiments under the advice of an expert; and in railroad history, at least, it has not generally been the scientific experts, either in physics or political economy, who have first shown the way to the big results. Private ownership encourages experiment; state ownership encourages stabilisation.

Such are the economic reasons which underlie and explain the fact that government management has been fairly successful on standardised industries, and habitually unsuccessful in progressive ones. As the electric industries constitute a field where there is exceptional room for progress in the immediate future, both on the operating and on the commercial side, it seems most undesirable that electric power generation should become a government monopoly at the present juncture. If a particular group of municipalities believes that it can get its light and power cheaper by organising a co-operative agency, let it do so; or if the government thinks that it can develop some of the nation's water power to better advantage than private companies, let it do so. But let it go into the competition on equal terms with private companies as to taxation and regulation. In this way, and in this way only can it prove whether it is really cheaper and better for the community. The history of state management of progressive industries in the last hundred years creates a strong presumption against the encouragement of government-owned electric plants by special privileges. Our brief experience with the electric industry itself has, in the opinion of the National Association of Railroad and Utilities Commissioners of the United States, tended strongly to confirm that presumption.

Under conditions like this the policy of exempting government-owned plants from taxation is an unwise one to continue, and the proposal to create a Government monopoly is wholly unwarranted by past experience.

VARIABLE-SPEED ELECTRIC BOAT WINCH; BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. VICKERS LIMITED, ENGINEERS, BARROW-IN-FURNESS.

Fig. 1.

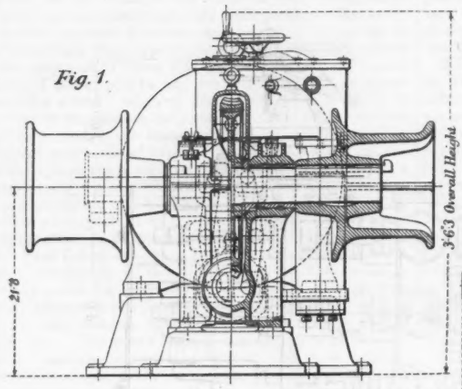
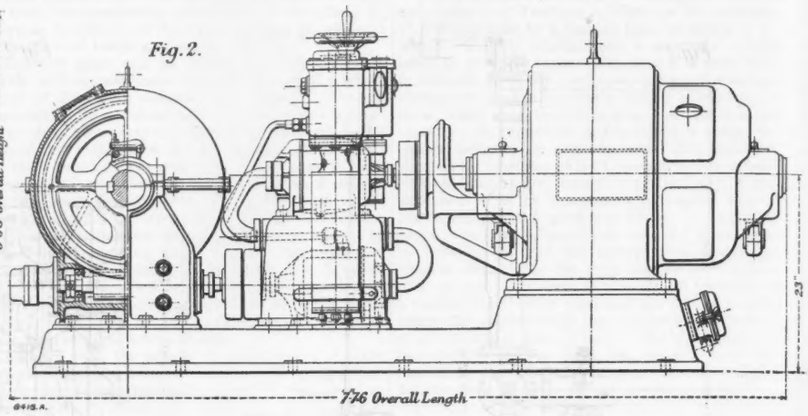


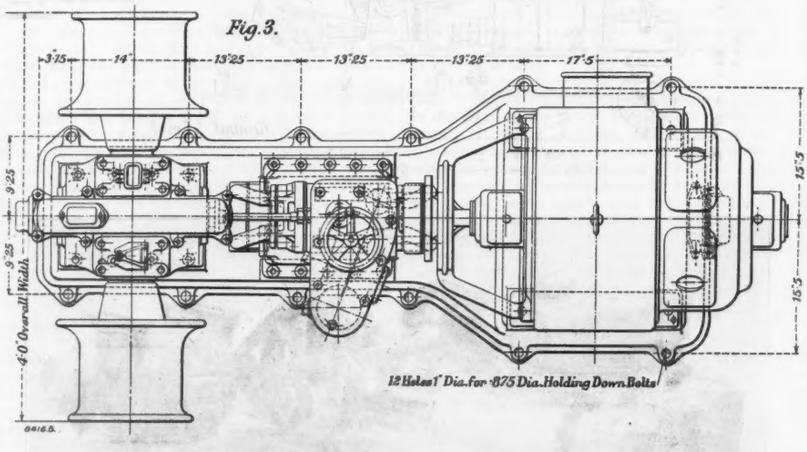
Fig. 2.



speeds from a constant speed power unit. One of the best known devices of this type is the Williams-Janney hydraulic variable-speed gear of The Variable Speed Gear Limited, of Broadway Court, Broadway, Westminster, an associated company of Messrs. Vickers Limited. Within the pump unit there is a cylinder barrel mounted upon the shaft which has a number of small cylinders bored in it having their axes parallel with that of the shaft. In each small cylinder there is a grooved trunk piston which is provided with a connecting rod, having spherical ends, connected respectively to a spherical seating in the piston and to one of a series of similar bearings in a socket ring mounted on the shaft. The ring is driven from the shaft by means of a universal joint and runs in two sets of roller bearings mounted in an inclined housing. The latter is mounted on trunnions so that its inclination may be changed. As the pump shaft is revolved, the cylinder barrel and socket ring rotate with it and a reciprocating motion is given to the small pistons. There are openings on the cylinder faces which are successively brought into communication with two ports cut through a valve plate. Through the first port oil is drawn into the cylinders, and there raised in pressure and then discharged through the other port. The stroke of the pumps and therefore the amount of oil dealt with may be varied at will by tilting the socket ring to a greater or less extent. When plane of the ring is adjusted to be at right angles to the shaft the pistons have no travel, and consequently there is no delivery of oil. Further tilting reverses the direction of motion of the oil. At the other end of the variable-speed gear there is a motor unit constructed in a similar manner to the pump, but with the enclosed housing which holds the socket ring, permanently fixed. As the motor unit receives its oil from the pump, the delivery of which may be varied in direction and magnitude, variable running in both direction and speed is obtained. This variable-speed gear has been applied to the drives of many different types of machines where variable speeds of working are essential, and on this page and the one opposite are illustrated two examples of winches in which it is incorporated. These form part of the exhibit of Messrs. Vickers Limited, at the British Empire Exhibition.

The first series of illustrations, Figs. 1 to 4, show a boat winch of the horizontal type, which will exert a pull of 30 cwt. at a speed of 90 ft. per minute. In this the power is obtained from a direct-current constant-speed motor of watertight construction, which develops 18 h.p. when running at 600 r.p.m. It is supplied with current at a pressure of 220 volts. The starter for the electric motor, which is of the contactor type, may be placed in any convenient sheltered position, and as it is operated from a double-push button mounting on the winch the operator need not leave his control position for starting up. A centrifugal brake is interposed between the electric motor and the pump unit of the variable-speed gear. As may be seen from Fig. 2, the pump unit is mounted on above the motor unit. The delivery from one to the other is effected by steel pipes. From the motor unit the drive is taken by a forged steel shaft, which has a worm cut on it. This worm drives a cast-iron worm wheel, which is provided with a phosphor-bronze rim. The entire worm gear is enclosed in a cast-iron oiltight gear case, designed to embody the bearings for the worm and main shaft, and in the base of which provision is made to take the end thrust of the worm. On the main shaft at each side of the gear box there is provided a warping drum of 12 in. diameter and 12 in. length outside the flanges. The whole design as may be judged from Fig. 4 is exceedingly compact, the operator has the push-button control for the motor at his hand and the variation of speed and direction of running may be easily and rapidly effected by altering the setting of the pump socket ring, by the use of the hand wheel, situated in a convenient position above the variable-speed gear. The electric motor is preserved from the consequences of excessive loading through the operation of an overload device.

Fig. 3.



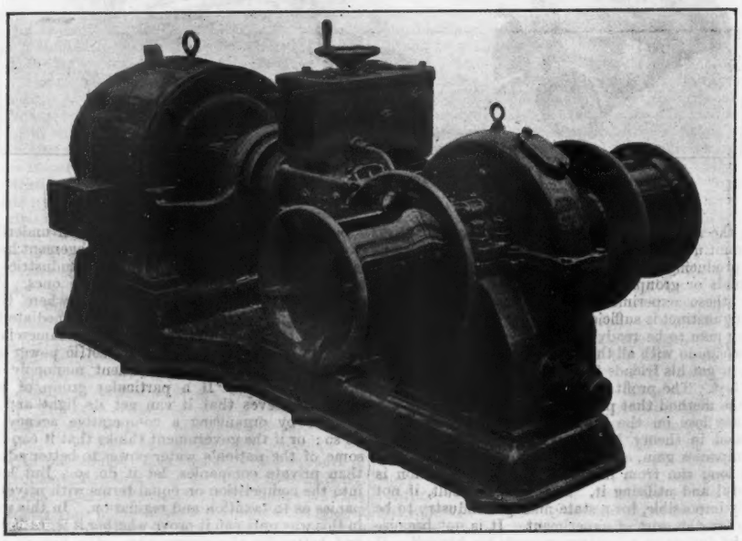


FIG. 4.

Another example of the use of the Williams-Janney gear, and one which shows the same characteristics of compact design and ease of control, is provided by the cargo winch illustrated in Figs. 5 to 8. This is of Messrs. Vickers' horizontal type, and can handle loads ranging from 1¼ tons at 150 ft. per minute, to, approximately 3½ tons, at 60 ft. per minute. The lay-out in

VARIABLE-SPEED ELECTRIC CARGO WINCH: BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. VICKERS LIMITED, ENGINEERS, BARROW-IN-FURNESS.

Fig. 5.

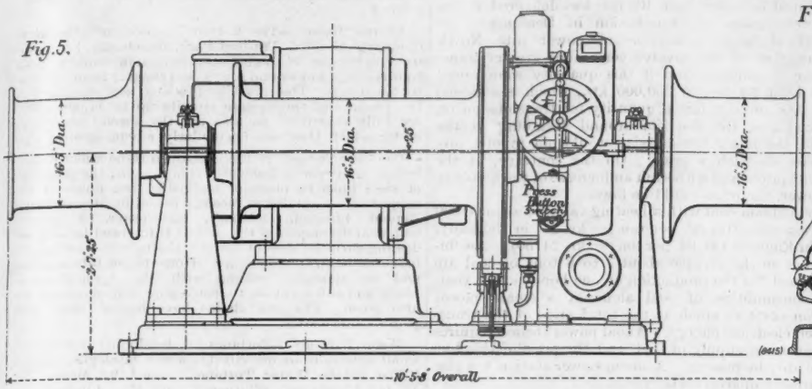


Fig. 6.

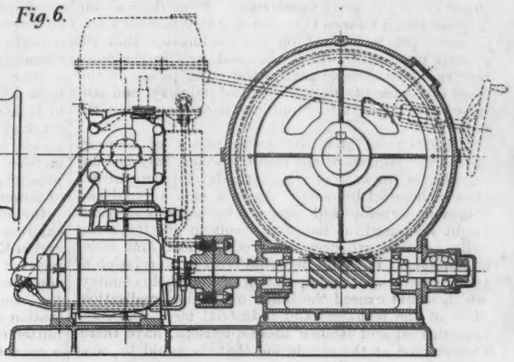
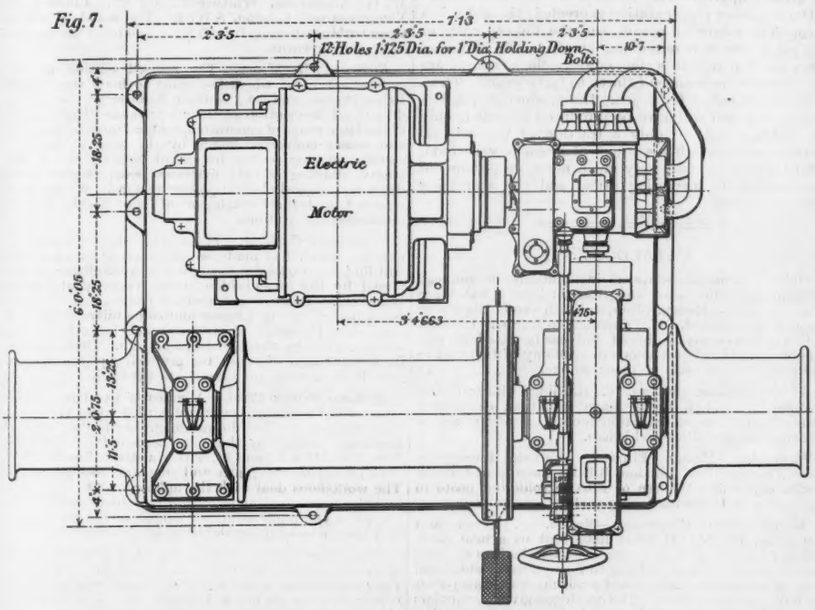


Fig. 7.



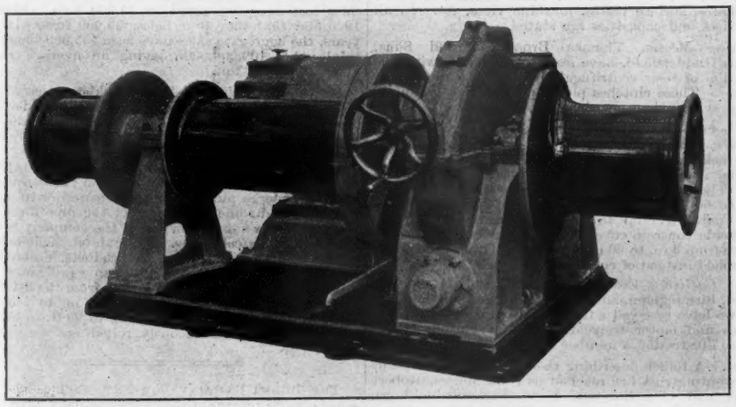


FIG. 8.

this case is quite different from the previous example, as the barrel being long is set with its axis parallel with the electric motor shaft. An electric motor, connected to a 220-volt direct-current supply, is provided and it develops 30 h.p. when running at the constant speed of 500 r.p.m. As the service to which these winches are put is one in which they are exposed, and therefore liable to the presence of water, the electric motor is of watertight construction. A motor starter of the contactor type is also used in this case for putting the motor into operation, and can therefore be placed in any position where it can be properly sheltered. Push buttons on the winch put it into and out of action. An overload device prevents the imposition of excessive loads on the electrical equipment. The drive from the motor is taken to the pump unit of the variable speed gear, a centrifugal brake being placed between them on the motor shaft. In this winch also the pump unit of the variable speed gear stands over the motor unit, but in this example the control wheel is not erected above the gear, but the spindle is made long enough to be carried through to the other side of the winch drum for convenience of operation.

The power obtained from the motor unit of the Williams-Janney equipment is carried through to the shaft on which the drums and barrel are mounted by a worm drive, which is clearly shown in Fig. 6. The worm and its shaft are formed from a single billet of forged steel and are effectively supported in ball bearings at each side of the foot of the gear casing, while a thrust bearing ensures the counterbalancing of end thrust. The worm wheel is a composite structure in which a phosphor bronze rim surrounds a cast-iron wheel. A barrel, 16½ in. diameter and 37 in. long, measured inside the flanges, occupies the central position on the main shaft, and there are drums 16½ in. diameter and 22 in. long at each end of it. For the support of the main shaft the bearings at the worm wheel serve at the one end, while a pedestal bearing erected between the drum and barrel meets the requirements at the other end. Beside the gear casing a powerful brake is provided, which has a Ferodo lining and is arranged for pedal operation.

Both of the equipments described are items in the range of standard winches made by Messrs. Vickers Limited, in which the Williams-Janney gear is used, and the components are all standardised and made to templates or to standard gauges.

EXPORT OF ELECTRICAL POWER FROM NORWAY.*

By S. KLOUMANN (Director of A/S Norsk Aluminium Company).

THE question of export of energy from Norway has for several years been discussed both in Norway and in our two neighbouring Scandinavian countries, Sweden and Denmark. Switzerland already exports considerable quantities of energy, and other countries might perhaps advantageously be supplied with power from Norway. When the Danish Government asked the Norwegian Government about the possibility of transmitting power from Norway to Denmark, a Scandinavian Commission was appointed by the Norwegian, Swedish and Danish Governments, comprising prominent engineers. The conclusions of the work of the Commission are summarised in a paper contributed to Section G of the Conference by Messrs. A. R. Angelo and W. Ring.†

In the Commission's report the upper limit of the prospective power transmission is assumed to be 100,000 kw., when the cost of energy will amount to 180 Danish kroner. The calculation has been based, however, on a rather high price, which presumably will fall, while the transmission of still larger quantities of power would further considerably lower the unit price of energy.

It seems, therefore, that the transmission of power from Norway to North Germany might offer considerable economical advantages to these two countries. Points of a political and social economic nature must be considered in the treatment and estimation of this particular case, and the political difficulties and opposing interests undoubtedly form a greater obstacle to the realisation of the idea than those of a technical and directly economic nature.

There are in Norway considerable political interests working to prevent the export of energy, in order to

* Paper, abridged, contributed to Section G of the World Power Conference on July 7, 1924.

† See page 114 *ante*.

keep it within the borders of the country to cover its prospective civil requirements, for development of our industry, and as a substitute for our coal consumption, &c.

How much power should be reserved in Norway for this it is very difficult to estimate. From data at our disposal it can be seen that Norway may reserve 1 kw. or more per inhabitant on the assumption that its present population will be doubled, and furthermore reserve a considerable part of the water power on the West Coast for the electro-chemical industry, and still have, say, about 1 to 2 millions horse-power left for export.

Utilisation of the total water power of Norway within the borders of the country would only be conceivable in the case of a gigantic development of our electro-chemical industry. Against such a rapid and enormous development very strong social objections might be raised, as liable to result in greater social evils and disturbances than economical and other advantages. It would necessitate a transformation of the character of the population of the whole country, which would exceed the limits of possible realisation. Most of the technical and industrial men, who have investigated and studied these questions, have therefore arrived at the conclusion that it would be most advantageous for Norway to reserve for its own requirements the necessary suitable water power, and otherwise be open for negotiations with foreign countries of Northern Europe, which might want to import electrical energy in order to compensate for their insufficient water power and coal supply.

The general view of the civil requirements of a country is that these are very low, because the estimate is usually based on the small development up to the present time. That this development has been small is due, however, to the production of power by means of coal, and consequent expense. It is the general view of Norwegian engineers that this development is also to a great extent dependent on the metering system. In Norway, with its permanent water-power source behind its distribution networks, the power is usually rented on the basis of what is called the balance-beam-meter system ("Vippesystem"). Each consumer rents a certain number of watts or kilowatts per year and pays an annual rent for this. An automatic balance beam cuts off the current the moment when this amount is exceeded, and turns it on again only when the consumption has been reduced to below the given maximum.

While this system may be said to cause certain difficulties for the consumers, such inconveniences are considered to be slight and easily overcome. This system has been responsible for the introduction of heat-accumulating cooking apparatus, which not only gives very satisfactory results from the culinary point of view, but has also considerably stimulated the introduction of cooking with electrical energy and the employment of the latter for heating as well as for a number of other purposes.

It is the general opinion in Norway that the extensive development of electrification, the large demands for energy, and the many advantages to home and industry which have accrued, are essentially due to the balance-beam-system, with its educating influence on the consumers, and to the lowering of the price at which the works can sell the energy when the consumption becomes more even and the peaks are reduced, to the advantage both of the producers and of the consumers.

It is clear that if electrical energy is to be advantageously transmitted over long distances and through large transmission networds, the peak load must be reduced as much as possible, and the consumption and utilisation of the energy must be as even as possible; in this way the transmission and distribution expenses will be correspondingly reduced. In Norway there are exampes of as much as 76 per cent. utilisation of the rented energy in comparatively recently-connected districts.

Export of electrical energy from Norway to North Germany, for example, might advantageously be carried on in the form of a more or less constant load which would be transmitted to large distribution networks, which would receive additional energy from steam power stations, the latter being responsible for the peak load. In some cities, as, for instance, Stockholm, the introduction of such a system has been considerably facilitated by means of the use of electrical auxiliary boilers which keep the steam power station ready for operation without coal-firing during those parts of the day and night in which they are not required; thus the station can step in with additional power immediately or at very short notice.

The import of power to North Germany and perhaps also to Holland, while local steam power stations could step in to equalise the load and carry the peak loads, would thus offer many and great advantages. The frequent strikes in the coal-mining industry also seem to call general attention to the importance of a power supply from a permanent source which is not dependent on such conditions. The coal supply released in this way might then be used for other districts situated more to the south.

As one of the findings of the Danish Committee, I have mentioned a price of kr. 180 per year for a transmission of not more than 100,000 kw. delivered at five different centres of distribution in Denmark. The import of larger quantities of power into North Germany would not involve very much greater transmission distances. And if this quantity were raised to at least 200,000 or 250,000 kw., which is assumed to be the suitable initial quantity for transmission to, for instance, the districts around Hamburg or the Baltic, the latter transmission would not involve any increase on such a price. On the contrary, at the present prices and with such an increase of the quantity of power, the price would be lower.

Good steam coal with a heating value of about 6,000 calories costs 16s. 6d. per ton (= kr. 26) in Germany, and in England 15s. 9d. per ton (= kr. 24·50). Assuming that on the average about 7 to 8 tons of coal are consumed for the production of one horse-power year, the consumption of coal alone of a steam power station costs as much as the total price of the transmitted electrical energy. A coal power station requires a continuous supply of fuel, and the price of this fuel is steadily increasing. A steam power station has also far greater upkeep costs.

Once a water power station is erected, the water is a permanent source of power, and the upkeep costs of the plant are at a minimum, at all events as far as concerns Norwegian water power. Such plants are amortised in the course of thirty to forty years. Thus, after the elapse of forty years the production price of the water power will have been reduced to include only the upkeep costs or only a fraction of the original production costs, whereas the coal steam power would, after forty years, cost very much more, on account of the continually increasing prices and the decreasing currency value.

CATALOGUES.

Induced Draught.—Several installations of induced draught are illustrated and described in a catalogue received from Messrs. James Keith and Blackman Company, Limited, 27, Farringdon-avenue, London, E.C. 4. The plant is simple and easily fitted to any chimney, and is advantageous in economy of fuel and in reducing the emission of black smoke.

Electric Motors.—Messrs. T. Harding Churton and Company, Limited, Leeds, have issued an excellently printed catalogue of induction motors, giving tables of dimensions, capacities and prices.

Hardening.—Messrs. Fluxite, Limited, Bevington-street, Bermondsey, London, S.E.16, have issued a new leaflet explaining the use of Fluxite soldering paste in hardening and case-hardening tools.

Machine-Shop Equipment.—Messrs. F. Pratt and Company, Limited, Halifax, have sent us a neat catalogue of lathe chucks, and supplementary leaflets showing sets of chuck jaws for bolting to face plates; additional sizes of independent and geared scroll chucks are also dealt with on separate sheets. The catalogue gives particulars of drill chucks, taper sleeves, lathe centres, steadies, angle plates, surface plates, machine vices, &c. In all cases prices and capacities are stated.

Clutches.—Messrs. Thomas Broadbent and Sons, Limited, Huddersfield, have issued a folder showing the application of their centrifugal clutches to a number of machines. These clutches pick up the drive gradually and slip at any given overload.

Pipes, &c.—Messrs. Cochrane and Company, Limited, Middlesbrough, have sent us a list of their products which include coal, pig-iron, coke and coke-oven by-products, iron castings up to 20 tons, and rust-proof pipes. The pipes are of three classes: cast-iron from 1½ in. to 60 in. diameter, lined centrifugally with concrete; mild steel up to 70 in. diameter with inside and outside concrete coverings; and centrifugally spun concrete from 3 in. to 60 in. diameter. Other linings are also applied instead of concrete.

Cycle Carriers.—From Messrs. F. and H. Melen, Limited, Birmingham, and 314, Gray's Inn-road, London, W.C., we have received a folder showing carrier bicycles, tricycles and motor tricycles fitted for various trades and also illustrating a number of trucks and hand carts.

Paint.—A folder describing their "Bowranite" paint for preventing rust has reached us from Messrs. Robert Bowran and Co., Limited, 4 St. Nicholas-buildings, Newcastle-on-Tyne. This paint, which, we understand, has stood severe tests, is made in black, red, grey and green colours.

Steel.—An interesting catalogue, specially issued for the British Empire Exhibition by the Cargo Fleet Iron Co. Limited, Middlesbrough contains a series of illustrations of their steel rolling and cutting plant, blast furnaces, gas plant, power station, pit-head plant, &c., and also gives a brief description of the operations of the firm and its subsidiary companies.

Sluice Valves.—A catalogue illustrating the details of construction of their sluice valves and comparing them with older methods of construction, has come to hand from Messrs. J. Blakeborough and Sons, Limited, Brighouse, Yorks.

Steel.—The South Durham Steel and Iron Co., Limited, West Hartlepool, have sent us a copy of a catalogue prepared for the British Empire Exhibition, giving illustrations of their steel-making and rolling plant and the related processes. The illustrations of the rolling, shearing, lifting and other machinery are of particular interest.

Electric Motors.—The Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, have sent us a catalogue of high-speed induction motors with squirrel-cage and wound rotors, and ranging from 100 h.p. to 5,000 h.p. The machines, which are suitable for two-phase and three-phase circuits up to 11,000 volts, are fully described, as also are the special conditions under which they are particularly advantageous.

Conveyor Chains.—What is claimed to be a new departure in conveyor and elevator chains—viz., the provision of steel links in place of malleable iron links—is the subject of a catalogue recently issued by Messrs. Hans Renold, Limited, Didsbury, Manchester. A general technical discussion of the subject is followed by sections dealing with the sizes of the new chains, the attachments manufactured, sprockets, &c. Horse-power tables, prices and an appendix dealing with the application of block and other chains to conveying and elevating are also given. The new chains have hollow studs and pierced side plates.

Water Turbines.—Turbines for developing power from small waterfalls are described in a new catalogue, entitled "The Estate Water Turbine," issued by Messrs. Sir W. G. Armstrong, Whitworth, and Co., Limited, 51, Victoria-street, London, S.W. 1. The standard sizes of these turbines develop from 3 h.p. to 50 h.p. from heads of 6 ft. and upwards.

Electrical Machinery.—The revised edition of their general catalogue which has come to hand from Messrs. Bruce Peebles and Co., Limited, Edinburgh, contains an illustrated description of their works, an illustrated list of the large range of generators, motors, motor-converters, and rotary converters made by the firm, as well as a section relating to the industrial applications of electricity, showing several machines with electric motor drive and several electric power stations. We have also received a leaflet catalogue of the Peebles-Reyrolle automatic sub-stations.

Centrifugal Castings.—Those interested in centrifugal casting, which has made so much progress since 1916, will find some useful information in a catalogue recently issued by the Sheepbridge Stokes Centrifugal Castings Company, Limited, Chesterfield. The catalogue contains notes describing the process and some microphotographs comparing the grain of castings made by ordinary sand moulding and by the centrifugal process. Drum castings, in a full range of sizes, for producing piston rings are now held in stock for immediate dispatch.

Railway Repair Plant.—A series of excellent illustrations of the repair and overhaul workshops of the Chilean State Railways at San Bernardo appears in the "Progress Reporter" issued by the Niles-Bement-Pond Company, New York, U.S.A., and 25, Victoria-street, London, S.W., who furnished the plans and machine tool equipment. The workshops deal with the upkeep of 300 locomotives and the corresponding passenger and goods rolling stock. Copies of the publication are issued in French, Spanish and Italian in addition to the English version.

Tin.—The Straits Trading Co., Limited, 11, Colyer-quay, Singapore, have sent us a pamphlet illustrating their tin refining works and plant, and giving particulars of the trade in tin ore and refined tin. The capacity of the works is 60,000 tons of refined tin a year, and the sales last year amounted to 45,500 tons, although in 1920 and 1921 they were below 30,000 tons. In twelve years, the aggregate sales have been 435,000 tons and the total value 100,000,000*l.*, giving an average value of about 230*l.* per ton.

Structural Steelwork.—Two booklets received from Messrs. Dorman, Long and Co., Limited, Middlesbrough, containing descriptions and lists of their products, and prepared more especially for the British Empire Exhibition, are of particular interest. There is a reproduction of a water-colour drawing shown at the exhibition of the new bridge for Sydney Harbour; illustrations of a number of large public buildings erected or in course of erection; and some particulars of the pipe lines for the Bombay water supply, for which the company is making 80,000 tons of steel plates. The exhibits include samples or specimens of coal, coke, by-products, firebricks, and chemical productions, in addition to a full range of steel rails, plates and sections. We note from the list that the company is producing plates from ¼ in. to 2 in. thick, from 15 in. to 45 in. wide, and up to 90 ft. in length, all of which are simultaneously rolled on the sides and edges.

THE BURMA RAILWAY COMPANY.—Some figures relating to traffic returns of the above company have recently come to hand. A comparison of the figures for the week ending June 14, 1924, with those the same week last year indicates an all-round increase for the same amount of track open, viz., 1,342 miles. Coaching and sundries have risen from Rs. 2,82,522 to Rs. 2,96,249, an increase of Rs. 13,727, or 980*l.* In the case of goods receipts Rs. 3,35,539 compares with Rs. 3,89,020, an increase of Rs. 53,481, or 3,800*l.*, making the increase in receipts Rs. 67,208, or 4,780*l.* The receipts per mile increased from Rs. 461 to Rs. 511, a difference of Rs. 50, or 3*l.* 13*s.*, while the average earnings per mile per week improved from Rs. 552 to Rs. 570, that is, by Rs. 18, or 1*l.* 5*s.* The total revenue from April 1 until June 14 last year was Rs. 81,95,822 as compared with Rs. 79,41,078 for the current year, an increase of Rs. 2,54,814, or 18,201*l.*